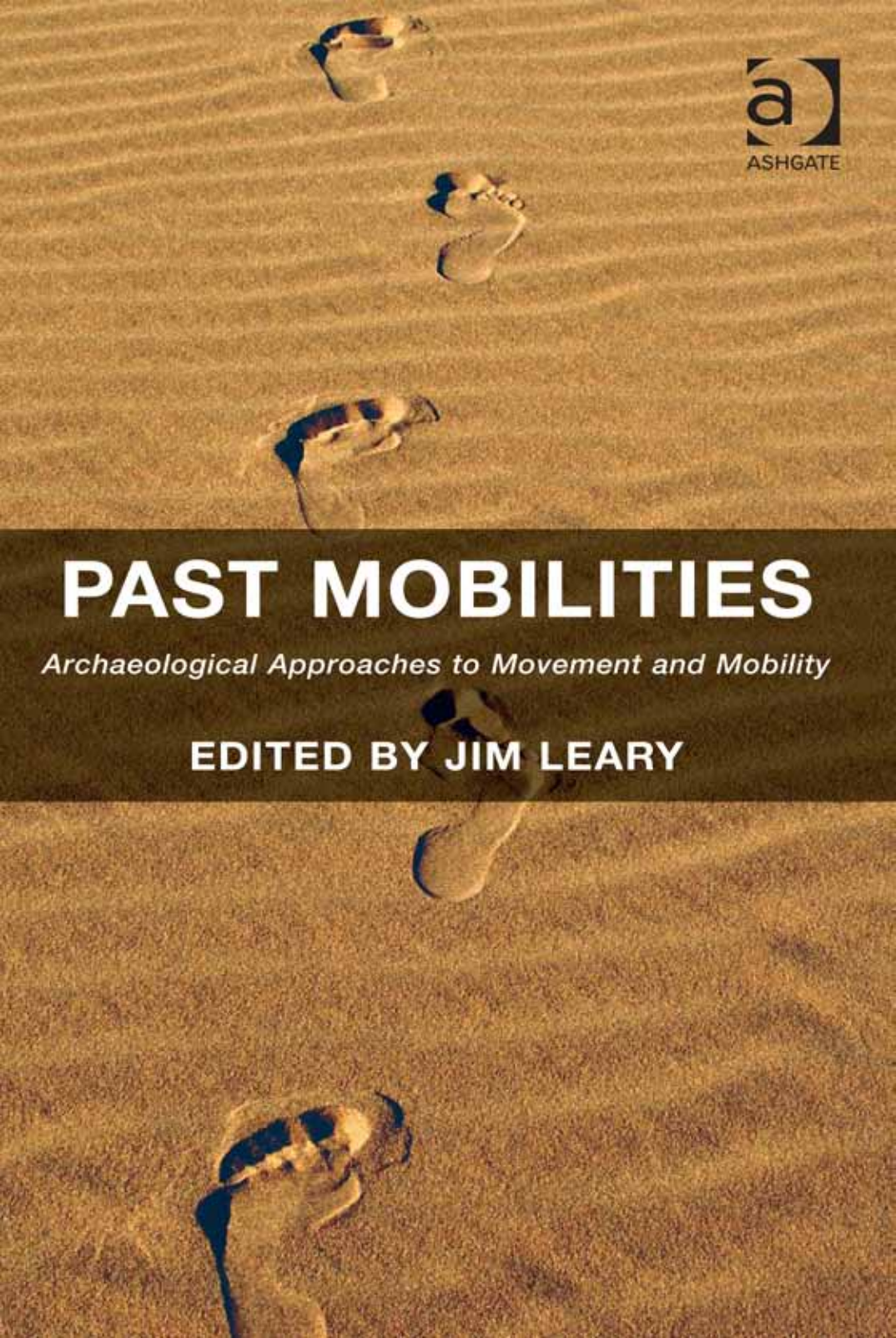
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PAST MOBILITIES
Archaeological Approaches to Movement and Mobility
EDITED BY JIM LEARY

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Past Mobilities

Archaeological Approaches to Movement and Mobility

Edited by

JIM LEARY
University of Reading, UK

ASHGATE

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Jim Leary
Mottisfont, August 2013

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Chapter 1
Past Mobility: An Introduction

Jim Leary

Introduction

On a warm summer's day, four young adults set off along the edge of an estuary foreshore. They walk alongside one another heading southeast. With every step their bare feet sink into the soft estuarine mud which squeezes up through their toes and clamps around their heels. It sucks and squelches as they move. They stride at a brisk pace. At one stage, one of them sees something and veers left, crossing the paths of the others and causing them to momentarily bunch together before spreading out once more. Four lines of flow: weaving, interacting and mingling together. Perhaps they are on their way to pick up something or coming home after delivering an item; or maybe they are out to undertake an entirely different task. Perhaps they are there to do nothing in particular; just out for a walk – to feel the summer sun on their necks and the cool, wet mud around their feet. Nearby a child of three or four plays with someone a few years older; perhaps a sibling. The younger of the two playfully, absent-mindedly, dances around the other leaving an erratic array of footprints in the mud. The older picks up something heavy (could it be the youngster?) and feels his or her feet sink, leaving noticeably deeper traces in the ground. Elsewhere a person steps out across the estuary in a straight line heading west. They walk at a steady pace, despite sliding twice in the mud, and halt momentarily, feet side-by-side, before continuing.

Movements like these are the stuff of life. They could be from anytime and anywhere – today, yesterday, last century. These particular flows happened at the end of the sixth and beginning of the fifth millennium BC, towards the end of the Mesolithic period, at a site now known as Goldcliff East in the Severn Estuary, UK (Bell 2007). The evidence comes from footprint-tracks recently exposed in banded sediments (of the Wentlooge Formation) on the edge of a former channel (Scales in Bell 2007 – although I add my own take, the first four people described above are based on 'Persons 2–5', the next two on 'Persons 11 and 12', and the last on 'Person 1'). The fine-grained sediments within which some of the clearest footprints were found were laid down during spring and summer months, and in some instances there is evidence of cracking in the mud suggesting that it was hot when the footprint was made or soon after. The prints were later sealed by coarser grained sandy bands deposited during the following autumn and winter, thus preserving them. This process was repeated yearly for over a thousand years, before sea-level rise eventually inundated the whole area. These fragmented tracks

now provide evidence for trails of humans and animals. From them it is possible to record stride length and cadence, as well as foot size – and from the latter a certain amount of data can be garnered on age and body size (Scales in Bell 2007). In particular, they provide tangible evidence for past mobility – the currents of life that make up human existence.

Figure 1.1 The footprint trails of 'Persons 11 and 12'
Source: Photograph from M. Bell; used with permission.

Mobility and archaeology

This is a book about past mobility. More specifically, it is about the movement and flows of people, ideas, objects and information from place to place, from one person to another. Mobility is all about us; it is both vital and ubiquitous. It can take the form of long journeys or migrations, or it can be undertaking tasks such as hunting, foraging, ploughing or making pots. Mobility can also be small actions – micro-gestures that form recognisable and repeatable practices making up everyday routines and habits. We come into this world moving and we learn about the world around us through movement; we attune to ourselves and to the world by moving and exploring (Sheets-Johnstone 2011a). Movement is primal: 'in the beginning was – and still is – movement' (Sheets-Johnstone 2011b: 124).

The development of the discipline of archaeology can almost be said to have emerged through movement. Some of our best known monuments were described by travellers and antiquarians touring the land, often on horseback. John Leland, commissioned by Henry VIII, extensively travelled England and Wales describing the topography and compiling maps. This work inspired a genre of tours and 'perambulations' by topographer-antiquarians who traversed the country describing features and prospects (Lancaster 2008). These included antiquarians William Camden, whose *Britannia* was printed in 1586, and John Aubrey, who wrote *Monumenta Britannica* in the seventeenth century, through to William Borlase and William Stukeley in the eighteenth century. It also includes the novelist and commentator Daniel Defoe and solitary horse-riding traveller Celia Fiennes, both of whom recorded their adventures and journeys. As travel became increasingly accessible throughout the eighteenth century more people were able to participate, visiting well-known monuments around the country. The 'Grand Tour', on the other hand, afforded the wealthy the opportunity to see the ancient sites of Europe and beyond (Lancaster 2008). Although, as Foubert and Breeze show in Chapter 9, tourism to historic sites flourished in the Roman Empire too (as did an associated trade in souvenirs).

Walking around is still the best way to explore archaeological sites and monuments, and can be an important part of the learning process through fieldtrips. Exploring archaeological monuments on foot is often used as a way of getting closer to the past – still today a visit to Avebury henge in Wiltshire, will see any number of people 'processing' along the West Kennet avenue, or, for that matter, along the Greater Cursus monument near Stonehenge. Similar fieldwork techniques are, in fact, well established within the phenomenology tradition of direct engagement with monuments in British archaeology (for example, Bender 2001, Brück 2005, Edmonds 2006, Gillings 2011, Tilley 1994).

Archaeological fieldwork, whether survey, excavation or any other approach, involves considerable mobility – that is to say – it is a physical task. This is particularly so with 'fieldwalking', where lines of archaeologists, head bowed, walk across a chosen area such as a recently ploughed field, and record objects lying on the surface. This is a form of walking that requires one to disengage from

almost all but the piece of ground immediately below. Archaeological excavation involves the movements of trowel, mattock and shovel; actions which reveal the archaeological deposits or follow the cut and remove the fill. On a micro-scale it also includes the rather less energetic movements of the sharpened pencil across permatrace to create drawn plans and sections. Pencil movements that depict (according to the excavator's interpretation and on the whole using standard conventions) the past movement of the soil – the tip lines and flows of backfill (McFadyen 2011). These 'lines of movement' are past actions depicted by present ones, recorded for future use (McFadyen 2011: 40–2).

Discussions of past mobility have occasionally entered into the archaeological literature, and are sometimes quite central – particularly with regard to the spread of people, cultures and artefacts (for example Kristiansen and Larsson 2006). Yet mobility is rarely studied directly as a subject in itself. More frequently it is treated as an aside, and often when discussed is framed in highly rational terms, generally through debates on optimal foraging strategies, and nomadism and sedentism (see, for example, papers in Barnard and Wendrich 2008). It is framed as cost and benefit, and the human-scale experience of mobility is often lost. Mobility strategies are chosen logically for their functional practicalities; it becomes an involuntary and behavioural reaction rather than a core component of the social world. This is what Ingold has criticised as a 'head over heels' approach (2004, 2011); that is, a belief that rational intelligence happens in the head; whilst the feet are simply a mechanical response to the brain. Perhaps, as Cresswell (2006) points out, this oversight is because mobility is an intangible subject to study, and archaeology in particular deals poorly with the fleeting. Mobility lacks a presence.

Place, on the other hand, does not; it is reassuringly tangible – there is something that one can see in the ground and excavate. Archaeologists like to have neatly bounded places; sites that can be drawn around, scheduled and territorialised. When the movement of, say, people or objects is discussed, it is the 'place' they came from or ended up that is highlighted – rarely discussed are the movements in between. Place is always the starting point, not mobility, for there is a preference for fixity rather than flow (Cresswell 2006). Studying only place, however, removes bodily movement from the discussion, and a stillness is imposed on the past.

If, however, the focus is shifted back to mobility and movement, we can see the landscape occupied by moving bodies interacting and affecting one another, much like the four people I started this chapter with, and with past movements influencing future ones. Place can then be seen as a pulsing node or confluence in a meshwork of different mobilities (Ingold 2009, 2011). 'By the interweaving of routes over time or concurrently, a place is made' (Lee and Ingold 2006: 78). Place, then, is not so much a definable, tangible 'thing' – more a confluence of movements.

Within the social sciences, the new mobilities paradigm (Hannam et al. 2006), or mobilities turn (Urry 2007), that has developed over the last few years (other publications include Adey 2010, Büscher and Urry 2011, Cresswell 2006,

Elliott and Urry 2010, Merriman 2012), has done much to critique the suggestion that human subjects think and act independently of their material worlds. It has re-framed society from a fixed form, to one that is composed of complex mobilities, highlighting the meanings and politics of mobility as well as the social implications of it. Life is made meaningful as people, objects and ideas are mobilised.

The new mobilities paradigm has much to add to archaeology, but as this book highlights, archaeology has much to add to these discussions too. It is not enough to straight forwardly 'borrow' from the new mobilities paradigm, but to advance it and in doing so situate archaeology centrally within discussions of mobility (see also Aldred and Sekedat 2011). Archaeology needs to discuss mobility, but to go beyond the fact of the journey (see, for example, papers in Cummings and Johnston 2007) in order to discuss the rhythms, meanings, complexities, performance and social relations of mobility, as well as how different mobilities effect people and groups.

This book treats mobility as a central theme in archaeology; the chapters are wide-ranging and methodological as well as theoretical, focusing specifically on movement itself, and its importance, as well as archaeology's distinctiveness. In Chapter 2, Aldred suggests that it is this very distinctiveness, its focus on materiality and temporality in particular, that has so much to offer mobility studies. He shows that by understanding the fluid mobilities (the flows) that connect and link sites and objects, a much more dynamic archaeology comes to the fore. Aldred uses routes between medieval and post-medieval Icelandic sites to exemplify these 'flows', providing a diachronic view of mobility and revealing how existing mobility patterns can influence subsequent ones.

'Chiefs!' exclaimed Robert Louis Stevenson on the opening of the Road of Gratitude in Samoa.

> Our road is not built to last a thousand years, yet in a sense it is. When a road is once built, it is a strange thing how it collects traffic, how every year as it goes on, more and more people are found to walk thereon, and others are raised up to repair and perpetuate it, and keep it alive; so that perhaps even this road of ours may, from reparation to reparation, continue to exist and be useful hundreds and hundreds of years after we are mingled in the dust. (Stevenson 1894: 398).

Mobility in the landscape

Archaeologists study at a landscape scale; indeed, landscape archaeology has become so popular in recent times as to have formed a separate sub-discipline. The environment around us, however, also moves; it is constantly in flux (Bender 2001). This is a point Edgeworth takes up in Chapter 3, describing how fords, and to some extent bridges, fluidly gather the landscape, pulling in people and animals to cross the river at that point. As Strohmayer (2011: 127) says: bridges (and here we can add fords too) 'help us think mobility more clearly'. The

landscape is configured in relation to these crossing places, which can become strategic, political or symbolic; a place for meetings and assemblies. Fords and bridges are therefore confluences in the landscape, but these nodes can themselves move or become abandoned as the river moves and changes, or as new bridges are constructed, diverting and reconfiguring the meshwork of paths and roads. This also means things are altered for people too – the settlements that rely on the routes and their traffic. Through two case studies, Edgeworth presents us with a swirling enmeshment of paths, droveways, routes, people and animals – strands of movement focused on river crossing points in a shifting 'flowscape'.

Frederick (Chapter 4) also takes a landscape approach, studying rock art through a mobilities lens. In particular she explores the relationship between the stillness and permanence of the rock art itself and the movement that underpins its creation. Despite the prominence given to the fixity of rock art in the literature, Frederick chooses to focus on the ways in which mobilities may be discerned. This ranges from depictions of dancing and hunting, to modern technologies of movement such as the aeroplane and the motorcar, and also of journeys to the spirit world. Through this discussion Frederick shows that a mobilities approach is an apt framework for examining the mark-making activities of cultures.

The use of Geographic Information Systems (GIS) is one way of representing and analysing potential past mobility patterns. Seitsonen et al. (Chapter 5) use GIS and Hägerstrand's time-geography to understand mobility, monuments and settlement sites in the Bronze Age environment of the Khanuy Valley in Mongolia. Taking a higher level view of mobility, they suggest that people moved between winter camps in the foothills and summer camps alongside the river, while monument settings may have ordered and guided mobility patterns; the world around affecting and affected by mobilities.

Mobile objects

Archaeology's focus on 'things' is another of its strengths, and just as neither people nor landscapes are static, nor are objects. 'Social, economic and cultural differences … push things from one place to another, or even obstruct their movement' (Hahn and Weiss 2013: 7). They move and shift through people, reflecting, to a certain extent, people's movements. But objects are also caught up in their own networks, moving between and across the flows of people as they are exchanged, given as gifts, or lost and found. They represent obligations and dependencies. Objects can also gather people and networks and pull them in, much like Edgeworth's fords, affecting the flow of others as people travel to them (Urry 2007); think here of religious relics, artefacts in museums, or artwork in galleries. There are also the movements and networks that surround the production or transformation of an object – they are always part of an 'enmeshment'. Other processes move objects too, such as gravity, erosion and decay, and as Aldred points out in Chapter 2, there are post-depositional processes that continue to

move objects even after they become buried. In this sense objects are 'flows of matter' (Hodder 2012: 160).

Objects also move through time as well as space – passed from one generation to the next as they become repositories for collective and intergenerational memories; heirlooms that represent 'material emblems of an ancestral past' (Gilchrist 2013: 170). The meanings of things are often fluid, changing throughout their use lives, rather than fixed, and objects themselves can change and transform through the process of movement in time and over space (Appadurai 1986, Hahn and Weiss 2013). Mobility can be a transformational process for things as well as people.

Objects found in the archaeological record, which mostly represents their point of deposition, can also often be traced to their point of origin. This is either through typology or the result of using scientific techniques, such as chemical analysis, to provenance the material. However, the flows that the objects have experienced during their lifetime can normally only be guessed at. Some stages of the use-life of materials, however, can be reconstructed by, for example, use-wear and residue analysis of stone tools – the analysis of microscopic wear and tear, or residues on the edges of tools (Gijn and Wentink 2013). The *chaîne opératoire* is another way of helping us follow the movements of things (for example Knappett 2011), and while it is normally used to understand the manufacturing process of things, it can also, as Aldred discusses in Chapter 2, be used to reveal mobilising and transforming processes.

People can go to great lengths to collect, mine or quarry materials, such as minerals or stones, acquiring them from a particular source and transporting them great distances. Often these places are themselves important, but the journey can be too. Boivin notes that 'the value of a mineral is very often related as much to the journey that was made to acquire it as to the mineral itself' (2004: 10). As Frederick sets out in Chapter 4, in Aboriginal Australia mineral pigments are exchanged over vast distances, and in some instances these can be linked to the travels of ancestral beings. It is the movement as much as the place that provides the meaning, and these mobile meanings are written into the objects.

Mobility and the body

Journeys, particularly over long distances, can often pose considerable difficulties, and frequently travel in antiquity resulted in illness and disease; the word 'travel' deriving from the fourteenth century word for 'toil' or 'labour'. That is to say that physical travel involved the embodied, corporeal movement of bodies – or what Urry describes as 'lumpy, fragile, aged, gendered, racialized bodies' (2007: 48). Movement is a physical, sensuous experience. It works at the scale of the body and involves it in its entirety – including sight, hearing, touch, and smell (Cresswell 2006). It uses the hands and the lungs, and could, for more physical journeys, also include pain; exposed to the elements, and with blisters,

muscle ache and insect bites (Adey 2010, Ingold 2004). As Lorimer points out 'the lingering afterglow, and embodied ache, felt on having come home (and "put your feet up") is one of the motivations for having gone out for a walk in the first place' (Lorimer 2011: 24). Mobility is also often entangled with feelings, desires and emotions, and indeed certain mobilities, such as, say, pilgrimages, may be undertaken in order to generate a particular feeling or emotion. And of course as the playful young child in this chapter's opening paragraph shows – movement is not necessarily linear or moving from A to B; like time, there is not a start and finish, but simply a continuation of the flow of life (Ingold 2011).

Mobility obviously does not need to comprise long-distance journeys, and Woolford and Dunn describe their Motion in Place Platform in Chapter 6, which uses motion capture to recreate micro-movements, exploring relationships between moving bodies and places. These micro-movements include sweeping out an Iron Age roundhouse and grinding grain with a quern stone. This was done first 'virtually' in a sterile studio, and then in a physically reconstructed roundhouse, showing how the environment and the materiality of the environment in which the tasks were undertaken affected and afforded different movements and mobilities. Crucial to this analysis of performed bodies is Gibson's concept of affordances.

These micro-movements are habituated bodily actions that form repetitive daily routines. They exist within a particular practice, within a *habitus*, and daily activities and movements such as these shape and perpetuate social life (Bourdieu 1977). Regular movements train and skill the body through repetitive action, but they also change and shape our bodies (Sofaer 2006). Davies et al. show very clearly in Chapter 7 how movements can be literally written into our bodies. Far from being a fixed structure, the skeleton is plastic and mouldable, and can provide insights into repetitive mobilities throughout a person's lifetime. A professional tennis player, for example, will have pronounced deposition of bone on their playing side compared to their non-playing side. When this is applied to archaeology inferences can be made about the mobilities of past populations through signatures engrained in the skeleton. Davies et al. illustrate this using case studies from European prehistory, principally the transition to agriculture and state formation in the Nile basin. From their work we can see that mobility and the body are constructive of one another. Mobility is irreducibly an embodied action – we are our movements!

Meaningful mobilities

People engage and interact with their surroundings so that both landscape and traveller are constructive of each other (Ingold 2004), but some movement is more engaged than others. Vergunst and Ingold describe a Roman army marching and how this is a disengaged form of mobility (2008: 13). Bodies are forced along at a given pace and are to some extent unresponsive to the environment they move through. Interaction on a march like this is minimal – head up, eyes forward,

deaf to the world, as they move along roads from one marching camp to the next. This is a very different way of moving, resulting in another way of perceiving the world. But Roman society was highly mobile as Foubert and Breeze show in Chapter 9, with extensive infrastructure, including roads, which afforded a speedy postal network that facilitated rapid communication. Movement and mobility enabled the Roman Empire, and, in turn, the Empire enabled greater mobility. The Roman army – cosmopolitan, multiracial and made up of people from across the Roman world – embodies this very mobility.

Roman mobility was also highly meaningful and political, and one's style of walking provided an identity, and separated the 'cultured' (that is to say Greek and Roman) from the barbarian other (O'Sullivan 2011). Just as culture can be expressed through say cloths or art, so too can it be through the way individuals move (Urry 2007). As with any society, it was for Romans more than a way of moving through space – it was a performance with the assumption that there was an audience to watch and appreciate, and to understand something of the walker's identity. As the Roman philosopher Seneca remarked 'we do not walk, we parade' (translated in O'Sullivan 2011: 32). Walking was an ambulatory performance, and by their movement through the urban setting one could advertise their status through motion. Other forms of performative mobility included, as O'Sullivan (2011: 53) notes, the triumphal parade, which was a 'mobile narrative of contemporary history', and the funeral procession, which was a 'mobile narrative of the past'.

One's gait was of particular importance to the Romans and separated men from women, and free men from slaves. Indeed, it was such a characteristic that 'a "family gait" was no less distinctive than a "family nose"' (O'Sullivan 2011: 16). This brings to mind the poet and essayist Sir Thomas Overbury's characterisation of an 'affectate traveller': 'his attire speaks *French* or *Italian*, and his gait cries, *Behold me*' (Overbury 1940 [1614]: 85). As Farnell says: 'movement practices of all kinds – both highly skilled and mundane – are complex, multilayered, multi-semiotic realms of knowledge that require *translation* from one situation and cultural context to another' (Farnell and Wood 2011: 91–2, emphasis in original).

Furthermore, it was thought that gait in the Roman world reflected the movement of the mind, so that walking represented a unified performance of both the mind and the body. At the heart of this is how Romans thought about their body, and the relationship of their body with personal identity. But it was also believed that there were intellectual benefits of walking. The history of this extends back to the Peripatetics of Greek philosophy, and was taken up again later by philosophers such as Rousseau in the eighteenth century and the urban *flâneurs* of nineteenth century Paris (Solnit 2001). It also has parallels with de Certeau's formulation of walking (Certeau 1984), and, to a certain extent, modern day psychogeographers. As Nietzsche exclaims in *Twilight of the Idols* 'only ideas *won by walking* have any value' (Nietzsche 1990 [1889]: 36, emphasis in translation). For Seneca, walking was also a metaphor for the journey to virtue: 'the sage does not need to

walk timidly or one step at a time; for his confidence in himself is so great … ' (translated in O'Sullivan 2011: 44).

Walking in the Roman world was clearly a profoundly social activity. This is as it always is and has been: 'not only do we walk because we are social beings, but we are also social beings because we walk' (Ingold and Vergunst 2008: 2). Some Roman villa gardens were designed to provide a private space that choreographed movements so that the householder could have ambling conversations with guests; a feature in common with the formal gardens and 'wilderness' walks of the seventeenth and eighteenth centuries AD. The rhythm of walking shaped the rhythm of talking, and *vice versa*.

The Roman infrastructure afforded travel and a veritable tourist industry flourished. But travel was not always safe, as Foubert and Breeze show in Chapter 9, and use of escorts or dogs to protect against dangers is attested. Travelling by sea was not necessarily any better, and piracy was a problem. While underlining the obvious but fundamental fact that the body is/was vulnerable, this serves to show that mobility is complex and relational.

Gendered mobilities

Walking in the Roman world also appears to have been explicitly gendered. Elite males, for example, were expected to exhibit self-control and decorum in their bodies – indeed, their gait justified their social status as much as conveying it. Young, free-born men were trained to walk the 'right way' (O'Sullivan 2011), to acquire the skill. The speed at which one walked at was also important – slaves ran but aristocratic men did not hurry (nor did they linger, lest they appear feminine), reflecting a cautious and considered persona. A women's gait, according to the ideal norm, was graceful but not ostentatious. As Ovid sets out in *Art of Love*, the 'dainty' woman 'swings her sides artfully, taking in air with her flowing tunic, and she haughtily takes measured steps', whereas the uncultured woman 'plods like the sunburned wife of an Umbrian farmer, and takes huge, straddling steps'. Ovid suggested that the ideal gait should be 'a middle ground' between the two (translated in O'Sullivan 2011: 28).

Foubert and Breeze highlight how women travellers in the Roman world were perceived, by contemporary authors at least, as 'transgressive', leading to a modern view that few women travelled. But as they set out in Chapter 9, recent archaeological work attests to the fact that Roman women of all ages and rank were highly mobile; a point also highlighted by Eckardt (2010) and her work on Roman diaspora communities. Similar assumptions is a theme picked up by Brown in Chapter 8, who points out that the spread of ideas and materials in prehistory is normally seen in the literature as the result of the heroic travels of men. But how much of this results from our own male-centred conceptions? Using scientific techniques, such as strontium isotope and mitochondrial DNA analyses, Brown redresses the balance by outlining the considerable, but often overlooked,

evidence for women on the move, shifting the focus away from male mobility. We should not assume that men travelled more than women in the past, not least for with it are implications for how we interpret the spread of material culture, knowledge and ideas. Women in prehistory, as Brown states, may well have been the 'movers and shakers'.

Mobilities of inequality

Mobility could have been a source of freedom, but it could also have been used to exert power over people and groups, as in exiles, slaves or prisoners of war (indeed imprisonment is forced immobility), reflecting inequalities of power. Some people had control over mobility and greater 'access' to it (were more motile), and others did not. To take an example, a series of economic depressions in late sixteenth and early seventeenth century AD England created a proliferation of dispossessed and highly mobile labourers. This shifting group was made up of young apprentices, peddlers, wage labourers, and mobile craftsmen, and most moved easily between any of these roles (Fumerton 2006). As poverty spread throughout this time whole families were driven onto the roads, and extreme poverty for some led to begging and theft. 'A beggar lives here in this vale of sorrow, and travels here today, and there tomorrow, the next day being neither here, nor there: but almost nowhere, and yet everywhere' (John Taylor, 1621, *The Praise, Antiquity, and Commodity of Beggary, Beggars, and Begging* quoted in Fumerton 2006: 56).

Tudor poor laws and official proclamations against vagabonds and beggars led to many becoming perpetually mobile, travelling the byways of rural and urban England (Fumerton 2006). Enforcement was, however, uneven and depended on age and gender amongst other things. Clearly to some the ability to roam regularly from place to place, job to job, relationship to relationship, indulging in alehouse pleasures, provided a libertine freedom that defied the otherwise repressive households. But for unmarried women by themselves this meant persecution where female freedom was linked with lewdness and illegitimate children (Fumerton 2006).

Different mobilities

Ways of movement vary radically depending on the terrain one is moving through (Ingold and Vergunst 2008, Urry 2007). That is to say the ground is textured, so that some terrain requires greater hardship and exertion than others, and clearly moving through woodland is different to, say, open ground or over upland areas (Vergunst 2008). In this way, the topography (as well as, amongst other things, the weather and the vegetation), to a certain extent, forces the form of mobility. Furthermore, as Ingold and Vergunst point out, the world 'teems with non-human forms of animal life' (2008: 10), which influence human movements. The animals

one moves with, whether hunter or herder, also condition movements – the speed one moves at, the routes one takes, and the trails one leaves behind (Gooch 2008). Moving with animals constitutes a different form of navigating the world. This acts as a counterpoint to any discussion of past mobility that sees it as a series of undifferentiated acts. Any understanding of past movement clearly has to take the affordances of the environment into consideration; itself, which as Edgeworth (Chapter 3) shows, is mobile.

There are also different forms of movement. In the Roman world, the use of escorts of considerable size around town provided conspicuous evidence for one's status, wealth and power – particularly the power to defend themselves or threaten others. Conversely, the decadent could move around the city in the relative refuge of a litter, literally and metaphorically lifting them above the masses (O'Sullivan 2011).

Much discussion on mobility centres around terrestrial landscape movement, however movement on water offers a different experience of travel. Dunkley surveys prehistoric watercraft in Britain in Chapter 10; this form of movement enabled people, animals and materials to travel along rivers, estuaries, coasts and across the seaways around Britain, and encouraged the dissemination of ideas. It also provided a means for a vast network of long distance contacts, the extent of which in prehistory has probably previously been under-estimated.

Travel by water can take many forms and each would have provided a different experience and perception of the environment. To a certain extent sailors and canoeists are caught up in, and need an understanding of, the different rhythms and movements of the water bodies they move through. To sail is to enter into a different realm of everydayness. But as Dunkley points out, travel by water did not just require knowledge of the water, itself highly variable, but of nautical astronomy too – to navigate seaways one needed an intimate understanding of the heavenly bodies. It is also worth considering the movements required to produce a boat – the physical actions and meshwork of interactions with people and materials that surround the manufacture process, locking people into the boat and its use. Boat mobility was a fundamentally different way of moving, it required different ways of knowing, seeing and being, and people's identities and social relations were created by it – the sea is 'in their blood' as Dunkley says.

Dunkley also mentions portage (carrying the boat between rivers), which may be evidenced by a cleat on one of the Bronze Age boats from Must Farm, Cambridgeshire, UK. This unique form of land/river boat movement usually requires the boat to be heaved-up on to one's head. Waskul and Waskul point out (in the context of modern canoeists in North America) that while there can often be limited social contact between different crafts on the water, 'portages are the primary place where one encounters people' (2009: 29). Portages can perhaps then be seen as nodes in a river journey; social confluences where people can pause to pass pleasantries, have discussions on conditions further upstream, or enquire as to purpose of travel. Portage sites may, over time, have become social arenas and meeting points.

Like horseback riding, boats bring places closer together – 'a time-space distanciation'; they afford greater connection, which in turn leads to responses of further mobility as ties are made. They also speed up mobility and the sensory perception of it, creating a 'time-space compression' where the landscape moves ever quicker so that one engages with the world around differently. The arrival of new forms of mobility, such as boats or horseback riding, in one region will also have affected others, possibly altering previously favoured routes, and effectively immobilising groups. Further, social inequalities are brought about by the use of boat or horse, as opposed to feet, as a form of travel – that is to say that new mobilities can create elites. And questions should be asked about how people resisted or adjusted to the threats posed by this sort of outside movement.

People are affected by mobility, either intentionally or unintentionally, in different ways – one group's mobility can reduce the mobility of another, whilst some mobilities are dependent on others. Mobility is often unevenly distributed and people are differently mobile. Some movements are unrestricted, others bounded; some are hard, requiring exertion, and others are easy. Some people are dependent on others in order to move, such as a mobility-impaired person (the ill, the old, the disabled, or the pregnant) (Adey 2010). In other words, some people have more mobility than others, and different people can gain access to different spaces.

Travelling with the pilgrims

Many of the themes discussed above, that is to say meaningful, political and gendered mobility, are exemplified by the act of going on a pilgrimage. Pilgrimage is a journey taken specifically for a religious purpose, usually as an act of devotion, supplication or the completion of a promise to a God or saint, and is motion, both physical and metaphorical. That is to say that going on a pilgrimage is to feel and experience the physical, as well as the spiritual. While pilgrimage is common to many religions, I draw here mainly from that in medieval Britain, where most people will have attempted at least one pilgrimage in their lifetime (Gilchrist and Sloane 2005).

There were many different types of pilgrims and motivations for pilgrimages, and these differences would have led to considerably different experiences of moving. Some pilgrimages were undertaken voluntarily; and for some being a pilgrim was a way of life – people that were constantly on the move and 'indistinguishable from vagabonds' (Webb 2000: xvi). Others undertook a pilgrimage to earn an indulgence, which became common in the twelfth century AD. Some pilgrims were seeking a miraculous cure from an illness or disease, or relief from chronic pain, while others conducted it barefoot or in fetters – making the experience considerably more painful (Webb 2000). The experience of pilgrim mobility was a highly varied one.

Others pilgrimages were overtly mobilities of freedom – such as those simply interested in getting together with a group of friends and neighbours and enjoying the experience of going somewhere either as a day out or for a slightly longer time. Often this occurred at particular times of the year in order to enjoy a religious festival at the pilgrimage site, and certainly fairs and games often accompanied the celebration of a saint's annual festivity.

However, pilgrimages were also a form of restriction and were imposed on people, usually by bishops, as penance or rather punishment for minor offences such as adultery. These pilgrimages may simply require the penitent to go to a particular cathedral and stand before the high altar with a candle during mass. Others forced people to go barefoot; or for William Covel, guilty of repeated adultery, to go 'naked but for his breeches' (Webb 2000: 236). It was clearly the public humiliation as much as the journey which was penitential here.

Pilgrimages were also gendered, so that while men could travel alone, women would be expected to have a male escort (Morrison 2000). Some shrines were restricted to men only – for example, women were forbidden to approach St Cuthbert's shrine in Durham Cathedral, and relics or images in Carthusian or Cistercian houses were generally not accessible to women (Webb 2000). There was also a restriction, if not an outright ban, on the mobility of nuns and other female religious in the late thirteenth and early fourteenth centuries AD (Webb 2000).

There was also a very clear social hierarchy involved in pilgrimages – people with money had a better, or at least very different, experience of the pilgrimage. Prosperity, for example, may have dictated how close one could get to a saint's shrine, as well as the form of travel such as on foot, on horseback (the protagonists of Chaucer's fourteenth-century *The Canterbury Tales* all had mounts), or by some other form of travel. Those with money could travel to the Holy Land, Spain or Rome, whilst a more humble person may only undertake a short journey to a local or perhaps regional shrine. Evidence for these travels in the archaeological record comes from pilgrim badges, emblems and tokens, and possibly scallop shells placed within burials (Gilchrist and Sloane 2005). The clothing on a fifteenth or sixteenth century pilgrim buried at Worcester Cathedral Priory indicates that he was a man of 'reasonable means', as does the location of his burial inside the cathedral (Gilchrist and Sloane 2005: 84). There are frequent records of wealthy people paying others to go on the pilgrimage for them. Indeed professional pilgrims seem to have developed as a viable form of employment, hiring themselves out to people with the money but not the time or ability to go on pilgrimage (Webb 2000); an immobile form of pilgrim travel.

Furthermore, pilgrims did not simply move independently through the landscape; they influenced and affected the world around them. For example, offerings at shrines and the purchase of pilgrim tokens were an important source of income to the church and it was in their interest to encourage more pilgrims. This meant improved access such as better roads, the benefits of which clearly went beyond just the pilgrims. Others also benefited from pilgrims; flourishing pilgrim traffic led to an increase in peddlers, traders, and vendors, as well as taverns and

hospices along pilgrim routes, and pilgrim fairs brought with them dance and theatre troupes. Thames ferrymen did very well by serving pilgrims travelling from East Anglia and Essex to Canterbury (Webb 2000). No doubt we can also add criminals as amongst those that benefited from large groups of pilgrims. As McCorriston states: pilgrimage was an 'intersection of economic and religious practice' (2011: 28).

Pilgrim mobility was so much more than going on a journey. Like any other form of mobility, it was political, varied, uneven and unfair. It was a gendered activity – available to one sex more than the other, and experienced very differently. Whereas pilgrimage was a form of freedom for one person, it was a constraint for the other, occasionally serving to humiliate and perhaps even marginalise. Overall it would have resulted in very different embodied experiences.

Figure 1.2 'Earthbound Plant' by Antony Gormley. The soles of a life-sized statue buried upside down outside the McDonald Institute for Archaeological Research, University of Cambridge

Source: Photograph by Lucy Farr; used with permission.

Moving on

This short discussion of mobility has barely scratched the surface, however, hopefully it has shown how ideas about, and practices of, mobility have always been capricious and inconsistent. Mobility was not simply 'movement', but: embodied movement, performative movement, potential movement, free movement, or restricted movement. And it was constitutive of economic, social and political relations. As Adey says, mobility 'underpins many of the material, social, political, economic and cultural processes operating in the world today and in the past' (2010: 31). Movement is an essential part of our lived experience. The discussions of mobility that see individuals as independent of their social and political worlds ignore the richness of the mobility experience; the power relations, meanings, embodiments and effects of mobility. Culture, society, and ideologies have been constructed through mobilities and it underpins and informs the way we see the world.

Mobility was imbued with meaning and power. It was an ensemble of freedom, opportunity, adventure and progress, and yet it was also a form of restriction. Relative immobility can be a form of resistance too, blocking the normal ordering rhythmic flows of everyday life. Mobility is sensual, experiential and performative and engrained with social activities and cultural practices. Moving in a crowd can be pleasurable, social and tactile with all bodies moving together, connecting and binding them, whilst solitary movement can be a form of meditation, a reflexive practice, perhaps even creative. Mobility can be conformity or it can be transgression. Mobility that is different to the cultural norm may be seen as deviance; something threatening, to be feared and suspicious of and often something to be controlled.

Mobility cannot be taken on its own – it is complex, relational and impacts on people differently, and warrants closer examination in archaeology. We need to throw away old assumptions and unquestioned conceptions about mobility, and develop an alternative framework, and through this aim to understand who had access to and was affected by mobility. We also need to better understand cultural mobility (see Greenblatt 2009) – what were the mechanisms of interaction, and how did they set others in motion?

Archaeologists ignore the new mobilities paradigm at their peril; equally social scientists operating within mobility studies ignore archaeology, and the temporal richness this involves, at theirs. This book is a call for an archaeology of movement rather than stasis and to develop a distinctive archaeological approach to mobility. This entails privileging movement over place, and explicitly accepting that movement and mobility is and always has been a source of meaning and knowledge for all humans.

References

Adey, P. 2010. *Mobility*. London: Routledge.

Aldred, O. and Sekedat, B. 2010. *Part 1 of Moving on to Mobility: Archaeological Ambulations on the Mobile World*. [Online: Archaeolog]. Available at: http://traumwerk.stanford.edu/archaeolog/2010/12/moving_on_to_mobility_archaeol.html [accessed: 24 November 2011].

Appadurai, A. (ed.) 1986. *The Social Life of Things: Commodities in Cultural Perspective*. Cambridge: Cambridge University Press.

Barnard, H. and Wendrich, W. 2008. *The Archaeology of Mobility. Old World and New World Nomadism*. Los Angeles, Ca.: UCLA Cotsen Institute of Archaeology (Cotsen Advanced Seminars 4).

Bender, B. 2001. Landscapes on-the-move. *Journal of Social Archaeology*, 1, 75–89.

Bell, M. 2007. *Prehistoric Coastal Communities: The Mesolithic in Western Britain*. York: Council for British Archaeology (CBA Research Report 149).

Boivin, N. 2004. From veneration to exploitation. Human engagement with the mineral world, in *Soils, Stones and Symbols: Cultural Perceptions of the Mineral World*, edited by N. Boivin and M.A. Owoc. London: UCL Press, 1–29.

Bourdieu, P. 1977. *Outline of a Theory of Practice*. Trans. R. Nice. Cambridge: Cambridge University Press.

Brück, J. 2005. Experiencing the past? The development of a phenomenological archaeology in British prehistory. *Archaeological Dialogues*, 12(1), 45–72.

Büscher, M. and Urry, J. (eds) 2011. *Mobile Methods*. London: Routledge.

Certeau, M. de 1984. *The Practice of Everyday Life*. Trans. S.F. Rendall. Berkeley, CA: University of California Press.

Cresswell, T. 2006. *On the Move. Mobility in the Modern Western World*. London: Routledge.

Cummings, V. and Johnston, R. (eds) 2007. *Prehistoric Journeys*. Oxford: Oxbow Books.

Eckardt, H. 2010. A long way from home: diaspora communities in Roman Britain, in *Roman diasporas: Archaeological approaches to mobility and diversity in the Roman Empire*, edited by H. Eckardt. Portsmouth, Rhode Island: Journal of Roman Archaeology (Supplementary Series 78), 99–130.

Edmonds, M. 2006. Who said romance was dead? *Journal of Material Culture*, 11(1–2), 167–88.

Elliott, A. and Urry, J. 2010. *Mobile Lives*. London: Routledge.

Farnell, B. and Wood, R.N. 2011. Performing precision and the limits of observation, in *Redrawing Anthropology. Materials, Movements, Lines*, edited by T. Ingold. Farnham: Ashgate, 91–113.

Fumerton, P. 2006. *Unsettled. The Culture of Mobility and the Working Poor in Early Modern England*. Chicago: University of Chicago Press.

Gijn, A. van and Wentink, K. 2013. The role of flint in mediating identities: The microscopic evidence, in *Mobility, Meaning and Transformations of Things*, edited by H.P. Hahn and H. Weiss. Oxford: Oxbow Books, 120–32.

Gilchrist, R. 2013. The materiality of medieval heirlooms: From biographical to sacred objects, in *Mobility, Meaning and Transformations of Things*, edited by H.P. Hahn and H. Weiss. Oxford: Oxbow Books, 170–82.

Gilchrist, R. and Sloane, B. 2005. *Requiem: The Medieval Monastic Cemetery in Britain*. London: Museum of London Archaeology Service.

Gillings, M. 2011. Chorography, phenomenology and the antiquarian tradition. *Cambridge Archaeological Journal*, 21(1), 53–63.

Gooch, P. 2008. Feet following hooves, in *Ways of Walking. Ethnography and Practice on Foot*, edited by T. Ingold and J.L. Vergunst. Farnham: Ashgate, 67–80.

Greenblatt, S. 2009. *Cultural Mobility: A Manifesto*. Cambridge: Cambridge University Press.

Hahn, H.P. and Weiss, H. 2013. Introduction: Biographies, travels and itineraries of things, in *Mobility, Meaning and Transformations of Things*, edited by H.P. Hahn and H. Weiss. Oxford: Oxbow Books, 1–14.

Hannam, K., Sheller, M. and Urry, J. 2006. Editorial: Mobilities, immobilities and moorings. *Mobilities*, 1(1), 1–22.

Hodder, I. 2012. *Entangled. An archaeology of the relationships between humans and things*. Chichester: Wiley-Blackwell.

Ingold, T. 2004. Culture on the ground. The world perceived through feet. *Journal of Material Culture*, 9(3), 315–40.

Ingold, T. 2009. Against space: Place, movement, knowledge, in *Boundless Worlds. An Anthropological Approach to Movement*, edited by P.W. Kirby. Oxford: Berghahn, 29–43.

Ingold, T. 2011. *Being Alive: Essays on Movement, Knowledge and Description*. London: Routledge.

Ingold, T. and Vergunst, J.L. 2008. Introduction, in *Ways of Walking. Ethnography and Practice on Foot*, edited by T. Ingold and J.L. Vergunst. Farnham: Ashgate, 1–19.

Knappett, C. 2011. Networks of objects, meshworks of things, in *Redrawing Anthropology. Materials, Movements, Lines*, edited by T. Ingold. Farnham: Ashgate, 45–63.

Kristiansen, K. and Larsson, T.B. 2006. *The Rise of Bronze Age Society. Travels, Transmissions and Transformations.* Cambridge: Cambridge University Press.

Lancaster, C. 2008. *Seeing England. Antiquaries, Travellers and Naturalists*. Stroud: Nonsuch.

Lee, J. and Ingold, T. 2006. Fieldwork on foot: Perceiving, routing, socializing, in *Locating the Field. Space, Place and Context in Anthropology*, edited by S. Coleman and P. Collins. Oxford: Berg, 67–85.

Lorimer, H. 2011. Walking: New forms and spaces for studies of pedestrianism, in *Geographies of mobilities: Practices, spaces, subjects*, edited by T. Cresswell and P. Merriman. Farnham: Ashgate, 19–33.

McCorriston, J. 2011. *Pilgrimage and Household in the Ancient Near East*. Cambridge: Cambridge University Press.

McFadyen, L. 2011. Practice drawing writing object, in *Redrawing Anthropology. Materials, Movements, Lines*, edited by T. Ingold. Farnham: Ashgate, 33–43.

Merriman, P. 2012. *Mobility, Space and Culture*. London: Routledge.

Morrison, S.S. 2000. *Women Pilgrims in Medieval England: Private Piety as Public Performance*. London: Routledge (Routledge Research in Medieval Studies 3).

Nietzsche, F. 1990 [1889]. *Twilight of the Idols*. Trans. R.J. Hollingdale. London: Penguin Classics.

O'Sullivan, T.M. 2011. *Walking in Roman Culture*. Cambridge: Cambridge University Press.

Overbury, T. 1940 [1614]. An affectate traveller, in *An Anthology of English Prose*, arranged by S.L. Edwards. London: J.M. Dent and sons Ltd.

Sheets-Johnstone, M. 2011a. *The Primacy of Movement*. Amersterdam/ Philadelphia: John Benjamins (Advances in Consciousness Research 82).

Sheets-Johnstone, M. 2011b. The imaginative consciousness of movement: Linear quality, kinaesthesia, language and life, in *Redrawing Anthropology. Materials, Movements, Lines*, edited by T. Ingold. Farnham: Ashgate, 115–28.

Sofaer, J. 2006. *The Body as Material Culture. A Theoretical Osteoarchaeology*. Cambridge: Cambridge University Press (Topics in Contemporary Archaeology).

Solnit, R. 2001. *Wanderlust. A History of Walking*. London: Verso.

Stevenson, R.L. 1940 [1894]. Address to the Chiefs on the opening of the Road of Gratitude, in *An Anthology of English Prose*, arranged by S.L. Edwards. London: J.M. Dent and sons Ltd.

Strohmayer, U. 2011. Bridges: Different conditions of mobile possibilities, in *Geographies of Mobilities: Practices, Spaces, Subjects*, edited by T. Cresswell and P. Merriman. Farnham: Ashgate, 119–35.

Tilley, C. 1994. *A Phenomenology of Landscape: Places, Paths, and Monuments*. Oxford: Berg.

Urry, J. 2007. *Mobilities*. Cambridge: Polity.

Vergunst, J.L. 2008. Taking a trip and taking care in everyday life, in *Ways of Walking. Ethnography and Practice on Foot*, edited by T. Ingold and J.L. Vergunst. Farnham: Ashgate, 105–21.

Waskul, D.D. and Waskul, M.E. 2009. Paddle and portage: The *travail* of BWCA Canoe travel, in *The Cultures of Alternative Mobilities. Routes Less Travelled*, edited by P. Vannini. Farnham: Ashgate, 21–37.

Webb, D. 2000. *Pilgrimage in Medieval England*. London: Hambledon and London.

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Chapter 2
Past Movements, Tomorrow's Anchors. On the Relational Entanglements Between Archaeological Mobilities

Oscar Aldred

> The ground is all memoranda and signatures; and every object covered over with hints.
>
> (Emerson 1903 (1850): 261)

Robert Macfarlane opens his book *The Old Ways* (2012) with a direct quote from Ralph Waldo Emerson. It is not Emerson as such, nor Macfarlane's engaging prose, that expresses the theme that this chapter discusses, but the attention that the quote gives to mobility in the material world through the notions of memoranda, signature and hints. And it does this in relation to *ground* and *objects*; in other words an archaeologist's landscape and sites. For surely, if we are to argue for the distinctiveness of archaeology's subject compared to other disciplines, it is its focus on materiality and temporality (c.f. Webmoor and Witmore 2008, Olsen 2010). But what I also want to argue is that another necessary subject is the point of contact and a concern with mobility. If archaeology does not engage with mobility, and specifically the agencies associated with human mobility in antiquity and in its contemporary practices, it is in danger of representing the past as a static image. Which is to say, an image of unconnected histories, which when reproduced bear no determining relevance for the path dependency of future agencies and material outcomes. The study of past landscape and sites – if not archaeology itself – demands greater attention to the union of eventful materialities and human mobilities.

Archaeology is playing catch-up again. Just as Structuralism was changing its direction in anthropology while archaeology was beginning to embrace it (Leach 1973: 763), so too is archaeology in danger of losing the capital it has 'stored' in advancing the mobility programme (which I will explain shortly). There has already been much work done on mobility in other disciplines, but the task still remains to situate mobility within archaeological practice and theory that both critical reviews the existing programme, but also adopts a practice/theory that works for archaeology. Simply applying themes and styles from other disciplines does not do credit to archaeology, nor does it contribute to the discussions on

mobility occurring widely in other disciplines. This chapter has a single aim: to examine what in the mobilities programme has potential for archaeology. As I have suggested, the intention is not to adopt Sheller and Urry's mobilities paradigm (2006), but rather to identify some divergences and suggest some possible avenues to pursue. This will be done by critically assessing the mobilities paradigm, setting up the argument for its use in archaeology, and examining some of the guiding principles in a short case study situated in Iceland.

Movement in social sciences

The mobilities paradigm, if one is to apply Sheller and Urry's phraseology, has been gaining momentum in recent years. There is the journal *Mobility*, articles in *Environment and Planning*, *Cultural Geographies*, as well as numerous books on the subject within the broader social sciences (for example, Adey 2010, Büscher et al. 2010, Cresswell 2006, Ingold and Vegunst 2008). By tracing a longer path back from the contemporary to the 1970s it is possible to track the influences derived from time geography, associated with, amongst others, Thorsten Hägerstrand, as well as to Allan Pred (e.g., Hägerstrand 1970, Hägerstrand and Pred 1981, Pred 1977, 1986). This was a part of the critique of network geography (Haggert and Chorley 1969) and a reaction to the dominant study of regional transport systems at the time. Hägerstrand can be credited with awakening mobility as a going concern for study, although time geography has on the whole been based on statistical methods and less about the humanity in the system which one can read was originally intended (c.f. Hägerstrand 1970). The contribution nonetheless that it offered was a method for compressing time and space – a temporalization of space, as it were – through the study of movement patterns. This is an aspect that remains fundamental to the mobilities paradigm's 'transcending the dichotomy between transport research and social research, putting social relations of travel and connecting different forms of transport with complex patterns of social experience conducted through communications at a-distance' (Sheller and Urry 2006: 208). In as much as the mobilities paradigm is conducted at a distance, much of the research in the emerging research is 'concerned first with the patterning, timing, and causation of *face-to-face* copresence' (Sheller and Urry 2006: 217; my italics).

What has gradually emerged since 2006 have been several themes on to which most subsequent mobilities discussions have latched on to; which have been felt in archaeology (*c.f.* Aldred and Sekedat 2010): co-presence; observation; in-betweeness; and fluid interdependence. These themes, while encapsulating the 'mobility turn' led towards particular conclusions about the state of contemporary research on mobility, again pointed out by Sheller and Urry. The argument for this is rather long as it is presented by Sheller and Urry, but it can be reduced to two firmly established elements in social sciences. The first element is a directed critique of *sedentarism*, the idea that stasis is normal. The mobility paradigm adopts the notion that its opposite dynamism is normal, or at least

more normal than stasis. The second is a reformulation of Deleuze and Guattari's *deterritorialization* (1988) which argues for an adjustment away from fixed, static structures in society – e.g. the nation as a container – towards more *liquid* states by examining 'how social entities comprise people, machines, and information/images in systems of movement' (Sheller and Urry 2006: 210). Thus, in all of the critique and redirection, several theories and methods have been suggested, the most useful of which simply calls for examining movement from a more mobile, dynamic perspective with a new set of tools.

Movement 'stored' in archaeology – a contemporary review

At this juncture, it is perhaps more useful to examine archaeology than to continue to discuss social sciences, by identifying what already exists that can help us formulate a mobile and dynamic *archaeological* response to the paradigm. But one of the questions I hope to answer is to ask whether there is a need to do so?

It is clear that the majority of archaeological research has directed most attention on the exact opposite of what the mobilities paradigm has suggested should be studied: a focus on sites as places of collation and accumulation from a fixed perspective (Bolender and Aldred 2013). However, this is all fine, except that it has made little head-way into the diverse range of ties that link one site to another through different kinds of fluid mobilities. Site formation and the archaeological record end-up being represented as static, or worse still, thought of as static entities. Furthermore, archaeology is abundant with *territorializations*, particularly in discussions about the durable and resilient structures that were associated with past agencies. Our conventional approach to the past *and* the adoption of certain tropes in archaeology, such as site, landscape, society, identity, are two reasons why archaeology has been so slow on the uptake of using the mobilities paradigm, and its antecedents. To take on the paradigm requires a radical overhaul of epistemologies (the structural methods used to examine the world) and ontologies (the relational construction of the past as a world in which people lived) on which archaeology is based. Yet, there are two long-standing currents (or *flows*) that have been enveloped by mobile thinking that might help archaeology find a greater voice so as to adopt more mobile thinking and approaches; one on the surface, and the other buried.

Flow one

Within the current that runs along the surface of archaeology, there are three dominant markers. The first surface is linked to archaeologies of prehistory, principally Mesolithic and Neolithic periods, which have drawn upon the ideas associated with mobile, nomadic people and cultures, and the movement of objects. The issue of colonization, spread, diffusion and invasion have all fed into

this mobile narrative (e.g. Childe 1956, Anthony 1990). More recently, there has been a second surface in which there have been discussions on what constitutes people and community identities, whether one could call individuals or groups sedentary or nomadic (e.g. Binford 1978). Even more recently, a third surface has been the presentation of infrastructures associated with past movement. These have gained currency in current studies, leading to some archaeologists to argue for a correlation between the state of a culture's mobile infrastructure and its complexity as a society (Trombold 1991, Snead et al. 2009).

While these studies all reveal the material nature of past movement and go some way to explicate their form and temporality, are they not saying anything more than movement occurred and it took a particular form? The adoption of movement as a theme in these studies is nothing more than a statement of the obvious, perhaps a banality. And this is how people tend to view the study of movement, which when put like this is a perfectly reasonable point to make. It is uncertain though, and left to speculation, to what extent archaeology might reach the aims of the mobilities paradigm where the intention is to examine 'the patterning, timing, and causation of face-to-face copresence'?

One can argue that the three 'surfaces' above address the pattern and timing, yet the causation – the social relation rather than just the material – is somewhat lacking. The deferment of causation to larger organizational structures such as identity and society are a dead-end of sorts; they can only advance the thinking about mobility so far. Mobility requires context and a bottom-up approach – a *thicker* description (after Geertz 1973) – not a general thesis or adoption of a condition whereby movement is black-boxed. So, to what extent do these kinds of studies on the currents of mobility that lie on the surface of our discipline actually add to our knowledge about past mobility? Significantly, it is precisely the criticisms that have been levied against conventional social sciences by Sheller and Urry that the theme of mobility on the surface archaeology confirms: that stasis is normal and a large degree of ring-fencing and territorialization. The replication of what we already know about society from the perspective of movement rarely adds anything to changing the perspective and orientation about the past, or how it is understood or examined. The unfortunate tendency is that the way in which movement on the surface tends to be thought about further solidifies the narratives about the past as a succession of place-markers – the solid material syndrome that Edgeworth refers to (2011: 88). These narratives do not study the ideas that suggest dynamism is more normal than stasis, or deterritorialize the past – to make connections between different places and people. In other words, the conventional approach to an archaeology of movement exemplified by flow one – these three surfaces – does no more than discuss past movement as a series of straight lines; in terms of the origins and destinations of events, that are also predictable and assuming in character. And in this way, past movement is *black-boxed*. Yet unpacking the black-box, or avoiding it altogether, may lead to some fruitful, perhaps more significant avenues concerning past mobility and the effect on archaeology's interpretation about the past.

Flow two

A buried and latent mobility however, exists in archaeology that is useful, though one is hard pushed to find it – hence why it is buried inside the inner workings of some contemporary practices. If Hägerstrand can be seen to connect with the disciplinary borrowing that was going on in archaeology through David Clarke and the development of spatial archaeology, it was Allan Pred's association with geography and sociology, particularly with Buttimer and Giddens, that infiltrated archaeology's post-processual approaches. In a discussion piece with Mike Pearson and Michael Shanks on performance and archaeology, Julian Thomas identifies the potential that time geography has for the study of archaeology, and in particular its use in shaping narratives about the past. What Thomas suggested was that the places along a route also provide an index with which to trace other 'routes' for archaeological narratives; in this sense movement is the 'raw stuff of narratives' (in relation to a discussion on time geography c.f. Pearson and Thomas 1994: 158). This extends time geography to archaeology, with the laudable aim of consolidating the spatial and temporal paths of individual histories – both in the past and in the present – by following the movements along life-paths as if 'an unfolding drama' (Lenntorp 1976). Although little explored (though see Pearson and Thomas 1994, Barrett 1994, Mlekuž 2010) this archaeological relation with time geography represents some innovative and useful thinking for foregrounding the relationship between archaeology and movement.

Examined through a genealogy in thought, this history lesson is instructive, but it is not so important for this narrative except drawing attention to the existence of a more radical thought in archaeology: that buried and lurking underneath the spatial, temporal and material 'paradigms' or veils that have been laid over archaeology in the last 20 years is a latent mobility. This latent mobility has hardly been explored, waiting for its moment of transformation. Before connecting it with some possible themes there are some specific challenges that archaeology needs to overcome.

The materiality of past movement – the first step

As Sheller and Urry draw attention to, identifying what subjects and objects of enquiry are appropriate is a matter of finding the right practical and theoretical tools with which to examine movement. The tools that Sheller and Urry use for the mobility 'turn' in the social sciences are being used to examine issues associated with an increasingly connected, speeded-up world, linking topics such as globalization with the possible outcomes such as the deterritorializing of states, nations, identities and belongings. These themes are by their nature broad, and encapsulating, but does archaeology also have these issues in mind when it thinks about mobility? What then are suitable subjects and objects, and

areas of examination? And what tools do we need to carry out mobilities studies in archaeology?

These questions need to be asked because I do not think that our objects and subjects are so alike at our specific level of enquiry as those used by social sciences, suggesting that we cannot simply adopt the tools and approaches that the social sciences have taken towards the study of mobility. One of the areas of potential that drives archaeology as a discipline is our relationship to the materiality of the past, suggesting that *objects* remain our *subject* to some extent. In specific terms, this has several implications for how archaeology should operate its concern for mobility. The archaeology of past movement operates in reverse to those understood in the 'face-to-face' mobilities that Sheller and Urry discuss. Our objects and subjects for movement have already moved, as it were. To take this idea a little further, our perspectives are primarily about movement as material, related to issues associated with materialization – movement that is *materialized*. In contrast the social sciences paradigm observes mobility as it happens. Thus, archaeology and social sciences to some extent operate at each end of a continuum, along which towards one end lies movement as a materializing process and towards the other the turn of its mobility as solid, materialized forms.

However, while the already moved materials are archaeology's concern, we have also at the core of practice contemporary movements: the ones that we adopt when we carry out excavation or landscape survey. The interface between these two positions – between the state of movement as already happened and materialized in the past, *and* our movements in interpreting these materials in the present – for this is where the interesting point of convergence lies – poses a number of challenges in translation. Namely, that although it is the material we examine to gain a picture of the past, the material acts as a pivot from which there are other equally interesting mobile questions to be examined. For example, the linearity of the movement operation, the relationship between different agents (human and nonhuman), the rhythms and choreographies associated with past movement, and the nature of movement's materialization. Furthermore, our own bodies are potential mobile subjects that can be used to gain knowledge of what it was like to move through a landscape using material features to help shape and guide those movements. This is somewhat similar to landscape phenomenology (e.g. Tilley 1994, Edmonds 2006), where the question has been directed towards understand the intersections with an external, material world, and the intentionality behind the construction of sites. The role of bodies in these processes of revealing the material in a more embodied way have helped to shape particular types of perspectives about the past; although usually, too little acknowledged.

The items I have just mentioned suggest that adopting the mobility paradigm 'as is' from social sciences is not in the best interests of what archaeology can gain from applying some of its own mobility thinking about the past. Nor does it help to identify what mobility can potentially contribute to other disciplines. Arguably, although not always, the social sciences' mobility is largely associated with the ephemeral and transitory, mobility as it is observed in motion, so to speak. As

I have suggested, archaeology is somewhat opposite. It has tended to focus on the fixed, permanent and structural, the observation of material things in which the moving bodies involved are our own. As I have also suggested, this poses a number of challenges. As Edgeworth has outlined, studying the fixed, static traces inherent in sites ultimately leads them to becoming somewhat anachronistic and without their dynamic properties (the fixed material syndrome – Edgeworth 2011). Archaeology's central challenge in adopting a more mobile approach to the past revolves around taking what appear to be the fixed, static material observations and *taking a step a back*. Only in this way is it possible for archaeology to examine the interstitial positioning in-between movement as material and the thicker descriptions associated with mobile materialities – on the move – used to formulate past movement. In other words, exploring the tension between materialized and materializing movements in which the material acts as a pivot means approaching the study of past mobility through the present, in which the archaeologists' body is used as a kind of surrogate for past bodies (the root of this idea associated with *material practices* – Lucas 2001: 202). What I want to examine in the next section is a case study with which to link this theoretical polemic on mobility with actual mobility materials.

Vatnsfjörður – a landscape in north-east Iceland

The farm Vatnsfjörður is a central place within the local district called *Reykjafjarðar og Mjóafjarðar við* Ísafjarðardjúp (see Figure 2.1). Located in the northwest of Iceland, in an area called Westfjords – *Vestfirðir* – Vatnsfjörður was one of the most important seats of wealth and power in Iceland's history when written sources on the history of Iceland were emerging in the thirteenth century (Milek 2011: 15–6). According to the *Book of Settlements* – a document detailing the settlement of Iceland between AD *c.*870 to 930, with the earliest extant version dating to around AD 1275–80 – Vatnsfjörður was settled by Snæbjörn Eyvindsson, who laid claim to a large tract of land between *Mjóifjörður* in the west and *Langidalur* in the east (Hermann and Edwards 1972: 71). In another source that was compiled in the mid-thirteenth century – according to the *Story of the Conversion* (*Kristni saga*) – it is mentioned that by AD 1118 Þórðr Þorvaldsson of Vatnsfjörður was one of the thirteen great chieftains in Iceland (Grønlie 2006: 51). What is more, Vatnsfjörður importance is illustrated by the fact that it was the only chieftain settlement specifically mentioned in the Westfjords region. Another later occupant of the farm at Vatnsfjörður, Þorvaldur Snorrason, established a church before AD 1200, and by 1273 it was reputed to be the second wealthiest church in Iceland (Milek 2011: 15–6).

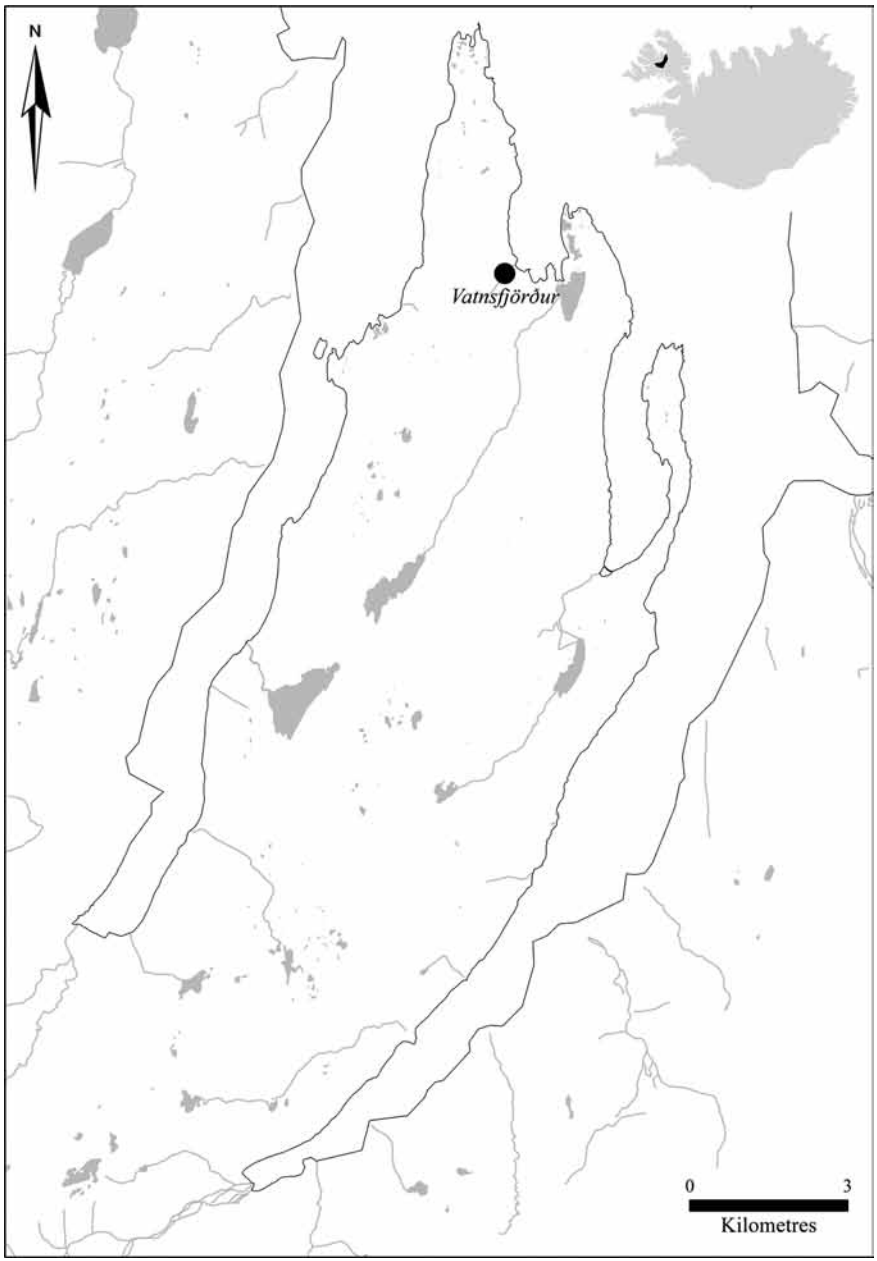

Figure 2.1 Map showing the study area (excluding the south-western area)

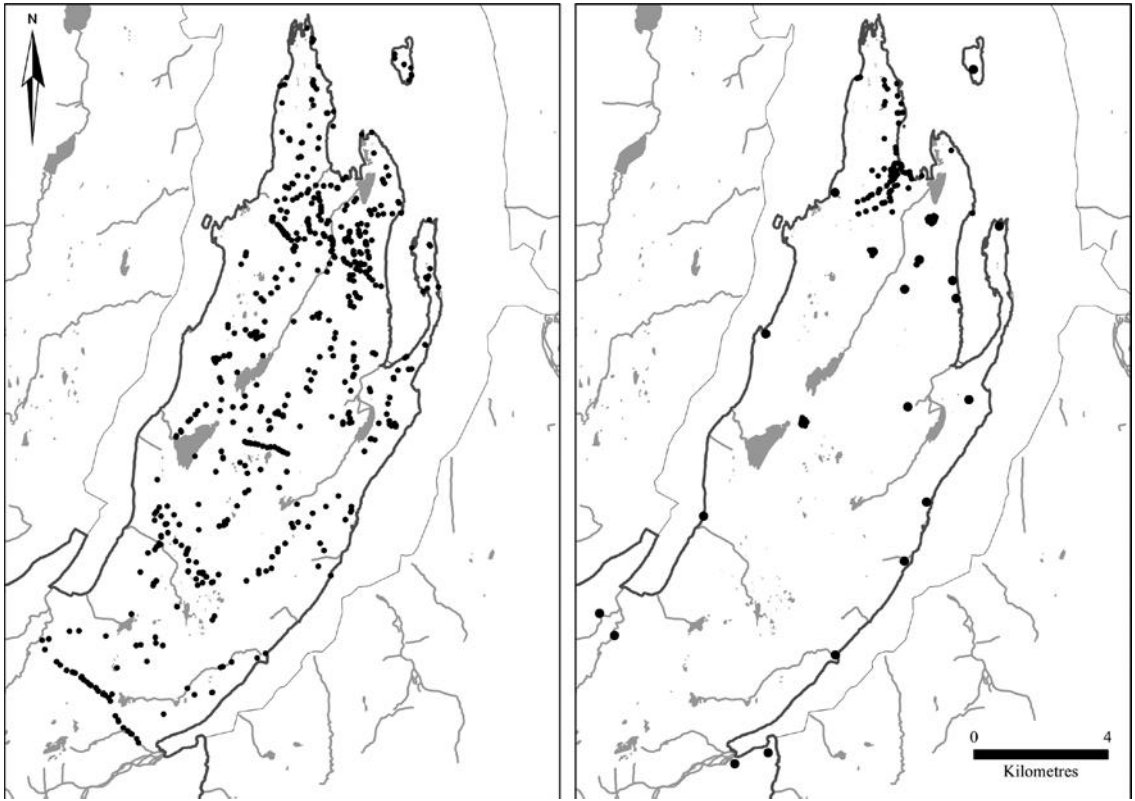

Figure 2.2 Two landscape archaeologies: 2005–2010 archaeological survey by author; 2010 archaeological survey using Icelandic methodology

Source: Hermansdóttir in Milek 2011.

During the thirteenth century Vatnsfjörður played a leading role in the politics of power in the Westfjords, and helped to shape the development of the Icelandic nation during the medieval period (Tulinius 2005). Between AD 1277 and 1342 Eiríkur Sveinbjarnarson – residing at Vatnsfjörður – was influential in the region as the head of the Norwegian court for the North and West of Iceland (Tulinius 2005: 12). By 1433, a part of Vatnsfjörður was owned by the church, who probably coveted the many rights that Vatnsfjörður owned, such as to farm produce, property and access to resources such as peatland, woodland, and driftwood in the north-west and other parts of Iceland. The farm remained wealthy throughout the sixteenth century, but appears to have lost its influence on domestic affairs by the mid-seventeenth century.

The settlement at Vatnsfjörður has been part of long-term research project that started with the excavation of the Viking period longhouse in 2003 and 2004 (Edvardsson 2003, 2004, Edvardsson and McGovern 2005), expanded in 2005 to continue excavation at Vatnsfjörður but also to study the surrounding landscape (Friðriksson et al. 2005), which has continued to do so every year since. The main objective has been to investigate the social, economic and environmental changes that have occurred at the farm of Vatnsfjörður and environs between its foundations (probably in the late-ninth to early-tenth century) to its recent history (twentieth century). The approach taken has been a multi-disciplinary one, incorporating textual, archaeological, and environmental evidence, from the collective experiences of an international team of archaeologists, historians, and natural scientists. In so far as the project has a single focus, it aims to investigate Vatnsfjörður as a seat of power has three research questions: to try explain why this farm was chosen as a chieftain's seat, specially its geographic location; what factors and social processes enabled Vatnsfjörður to flourish as a social, economic and cultural centre between thirteenth to seventeenth centuries; and why its importance declined during the seventeenth century (Milek 2011).

The majority of the fieldwork and use of resources have been directed towards two major excavation areas: the Viking period settlement area, and the early modern farm at Vatnsfjörður. However, the programme of landscape research, while regarding the social, economic and political efficacy of a place like Vatnsfjörður, alongside environmental work (Milek 2011), has also explored the practices past movement. Archaeological survey has occurred in two areas: *inside* the infield areas of the 19 farms in the region, but also the areas outside the infield and in the spaces in-between settlements. The two surveys are presented side-by-side in Figure 2.2.

Without going into too much detail about the surveys, over 60% of all sites surveyed in the Vatnsfjörður area were cairns (*c.*570; Figures 2.3 and 2.4). These sites are small stone built features (typically around one metre wide and tall), used for a variety of purposes such as marking boundaries, memorializing folklore, acting as time markers. However, a significant use of cairns was in guiding iterative movement; whereby cairns acted as waymarkers that were spatially extensive across the landscape. Furthermore, there were mobilities associated

with these other uses, such as memorializing events, ascribing folklore to 'wild' areas as they were moved through, as well as moving to specific locations in the landscape for time marking and in ensuring the confinement of territory in boundary creation. Besides identifying the potential multiple uses at each cairn, the site was recorded, photographed and located using a GPS. From this data, it has also been possible to reconstruct the material infrastructure relating to movement in a community; a series of routes that dates to at least the late-ninth to early-tenth century in some places, but which have had much longer lasting use into the mid-twentieth century. Today, the cairns are a relict feature, hidden amongst a modern transportation infrastructure of tarmac and gravel roads. Many of the cairns can potentially be dated to the formative phase in the medieval period, if not earlier. Although questions of dating are important in this respect, to examine the nature of change in movement practices and in marking practices over time, distract from the principal aim of this chapter: to demonstrate the potential of examining past movement in the present through the shared interface of the material itself. To do this we need to situate moving bodies with the material evidence of movement. As I have suggested, contemporary archaeologists are surrogates for past bodies, and quite literally through them it is possible to *inhabit past movement*.

Figure 2.3 A typical cairn; a fusion of nature and culture (uid 502)

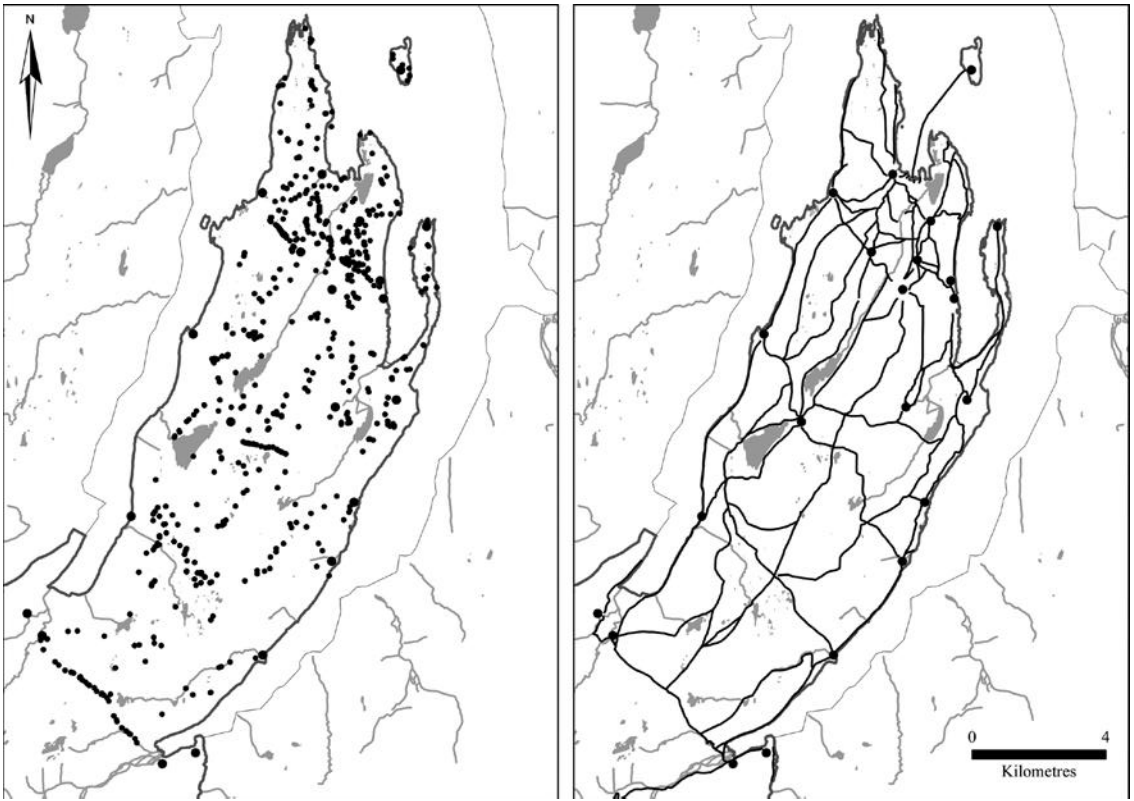

Figure 2.4 Cairns (left) and reconstructed tracks (right) with farms juxtaposed (larger black dots)

There are several ways to inhabit movement. To move through a landscape is to dwell in movement, occurring when one relates to and reflects on the material world as it is experienced and moved through. There is parity therefore in inhabiting movement and landscape in the juxtaposition of moving bodies and material systems that were part of the movement operation. In the case study around Vatnsfjörður sites such as cairns were associated with routes across the landscape that have been reconstructed. Whereas, the material systems are the fixed, immobile structural anchors that guided movement and have continued to guide movement as survey targets, the moving bodies are the living, highly dynamic properties in the movement relationship. Unlike the structural anchors which act somewhat passively during a movement operation, moving bodies actively negotiate the passage of movement by either choosing to follow guides or not, and making the decisions concerning origins, destinations, direction as well as speed.

The underlying assumption is that the people in the past principally used the routes marked by cairns to guide and take them to different parts of the landscape. This does not exclude other kinds of movements, such as those that were unmarked, just that the empirical 'science' that archaeology is a part of requires hard, material evidence and so it is impossible to enter into a discourse about these un-materialized movements without resorting to an unsubstantiated and speculated argument. However, the acceptance of the fact that not all mobilities have become materialized leaves the question of movement usefully open ended. Archaeologists cannot inhabit or know *all* past movements; this would be a rare thing indeed. This also distinguishes an archaeology of movement from other disciplines about mobility. Archaeology addresses the fragments of past mobility by piecing together the recurring, materialized movements. It has been suggested that archaeologists work on what is left (Shanks 2012) or that what remains residual does so because it is important and has continued to have value for each event of re-negotiation (Lucas 2008). The remains in the landscape, and how we understand the reasons for past movement – within the operation of movement – therefore requires a different set of parameters to be considered. But in order to conceive the immaterial – like much of past movement – archaeology tries to understand it in material terms (Buchli 2010: 185). The entry point for understanding movement in material terms in the case study comes from considering the mobile materiality of cairns.

The construction of cairns in forming routes suggests they were large investments in time and resources, and immediately tells us something about a particular kind of past movement in this landscape: that is was important to mark routes for *iterative movement*. In this type of movement there was a deliberate intentionality behind the construction of cairns and the formation of routes, which were from time to time repaired, maintained and altered. Thus, it is also possible to discern different phases of construction, use and alteration, demonstrated by the variations in styles and the rebuilding of cairns along many of the routes. However, while the material tells us a lot about *potential* use and function, it is

only through using our own bodies that we begin to enter into a dialogue about *actual* past movement – about the *tactics* of past movement (Aldred 2014). There are two sets of tools that can be used to tease movement from archaeological objects: operational chains and rhythmanalysis.

Cairns, routes and operational chains

Chaîne opératoire or operational chain was Leroi-Gourhan's extension of Mauss' *Body techniques* (Leroi-Gourhan 1993, Mauss 1979) and expresses a simple idea: a series of interdependent processes that are connected to one another along a chain of 'material' transformations. In archaeology the operational chain idea has been used to examine mostly artefact production (Lemonnier 1993, *contra* Warnier 2009). And this has generally been used to reflect upon technical processes associated with the 'manu-facture' of objects through 'a series of operations which brings a primary material from its natural state to a fabricated state' (Cresswell 1976: 6, quoted by Lemonnier 1986: 149); in other words expressing a kind of linearity.

More recently, the idea of 'material' transformation has been applied to bodies as well, and the co-constituent forces that are involved in any transformation along an interconnected chain (Dobres 2000, Naji and Douny 2009, Warnier 2001, 2009, Coupaye 2009). In this respect, the *objects* of primary interest for an archaeology of movement are things like cairns but also moving bodies when they enter the chain. The feature of linearity and co-constituents in an operation of movement, also lead to considering resonance and feedback associated with the path dependency of movement. So while cairns have a fixed, material presence in the landscape, when they are viewed through practices that actually involve motion, they become mobilized, as it were. Mobilized in the sense that they were viewed multiple times, each time differently, at particular junctures along a route bringing into play different forces; c.f. route 2 (Figure 2.5).

The basic operational chain as a pure sequence is constructed by arranging the passage of moving past each cairn, one by one. This also allows the basic operational chain to be expanded as a kind of narrative device, in a way like the time geography affect discussed earlier. For example, from Reykjafjörður the route that follows the cairns upslope takes the easiest route up through the basalt strata that created geological benches defining the ridge over which route 2 traverses. By following the route it is possible to reproduce another operational chain [with cairns that correspond to the numbers in Figure 2.5]:

> Upslope [1,2,3,4] — Flat [4,5,6,7] — Upslope [7,8,9] — Flat [9,10,11,12] — Downslope [11,12,13,14,15,16,17]

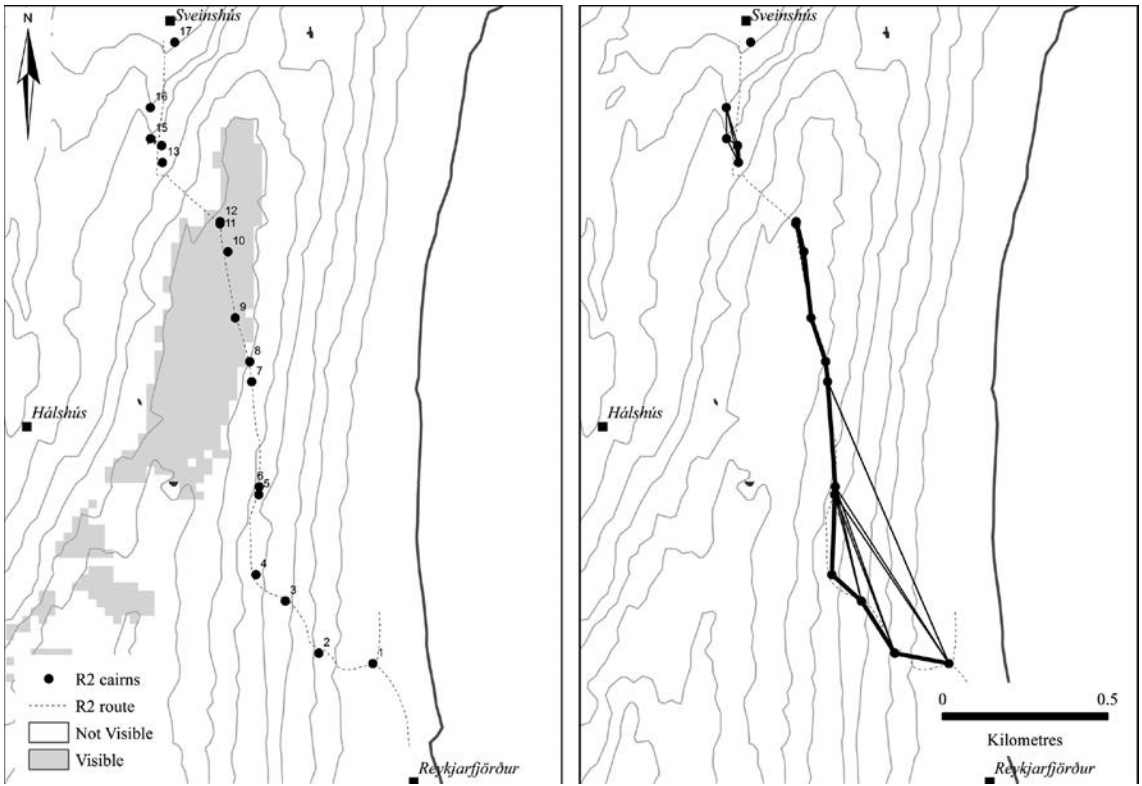

Figure 2.5 Visual envelope (viewshed) from cairns 11 and 12 (left), and the visual connections between cairns (right) along route 2

This ordering represents an *internal logic* to the movement operation, but only in one direction. In the opposite direct there is a different chain. In the direction from one farm, Reykjafjörður, to another called Sveinshús, there is a greater visual affordance at the start of the route as many of the cairns (cairns 1–7) are visible to one another. Arguably, cairns were made more mobile by being visible from multiple view points along a route. Visibility was enhanced through design and placement such as by being built on outcrops that elevated their visual affordance, as well as located on edges of the basalt bench (as in cairns 1–6). But the cairns, in general, are also mobile in the sense that they have been built from local stones gathered from around the cairn (but occasionally brought from elsewhere), and built according to different designs, that defines the route up into a series of other stages and other operational chains.

For example, it is possible to explicate the route as a series of transitions through the landscape derived from the staged affect that comes from the actual operation of movement,: from the farm, out of the domesticated land – beyond the homefield boundary, to the ridge (Reykjarfjarðarháls) that separates two settlement areas from one another across which there is a degree of superstition (cairn 11, Figure 2.5), to the next farm's domesticated land – at Sveinshús at which there are is a welcoming 'gateway' cairn arrangement along a 'corridor' formed by an old river channel. However, this is a description of the route as another operational chain, but does little more than the previous chain as it describes the topography. However, what is beginning to be revealed are the locales of transformative states through which a person moving along this route would have experienced. Thus, a more revealing operational chain is one that defines more pertinently the on-the-move relationship between the material organization of the cairns and the bodies moving along the route.

> Material corridor ─ Junction ─ Visual links ─ Between farms ─ Gateway ─ Topographic corridor

The material transition points along the route itself, and how one stage dissipated into the next suggests the 'in-togetherness' of movement corresponding with a series of different parts that also behave as a continuum and as a series of transitions. For example, the material systems such as cairns, the underlying topographies, and the people that used them to move from one farm to the next or for other more specific activities such as going to church. Figure 2.6 suggests a possible operational sequence as a narrative that identifies and defines transitions along the route that are defined by their co-constituent set of relationships between different parts; mobilizing the cairns and bodies into a single movement project. This perspective is also a way of addressing an archaeological problem that underlies the study of themes like past movement: how to study a dynamic and mobile practice from fixed and static remains. One technique that is applied through the operational chain, and which archaeology finds itself in continually, is that in

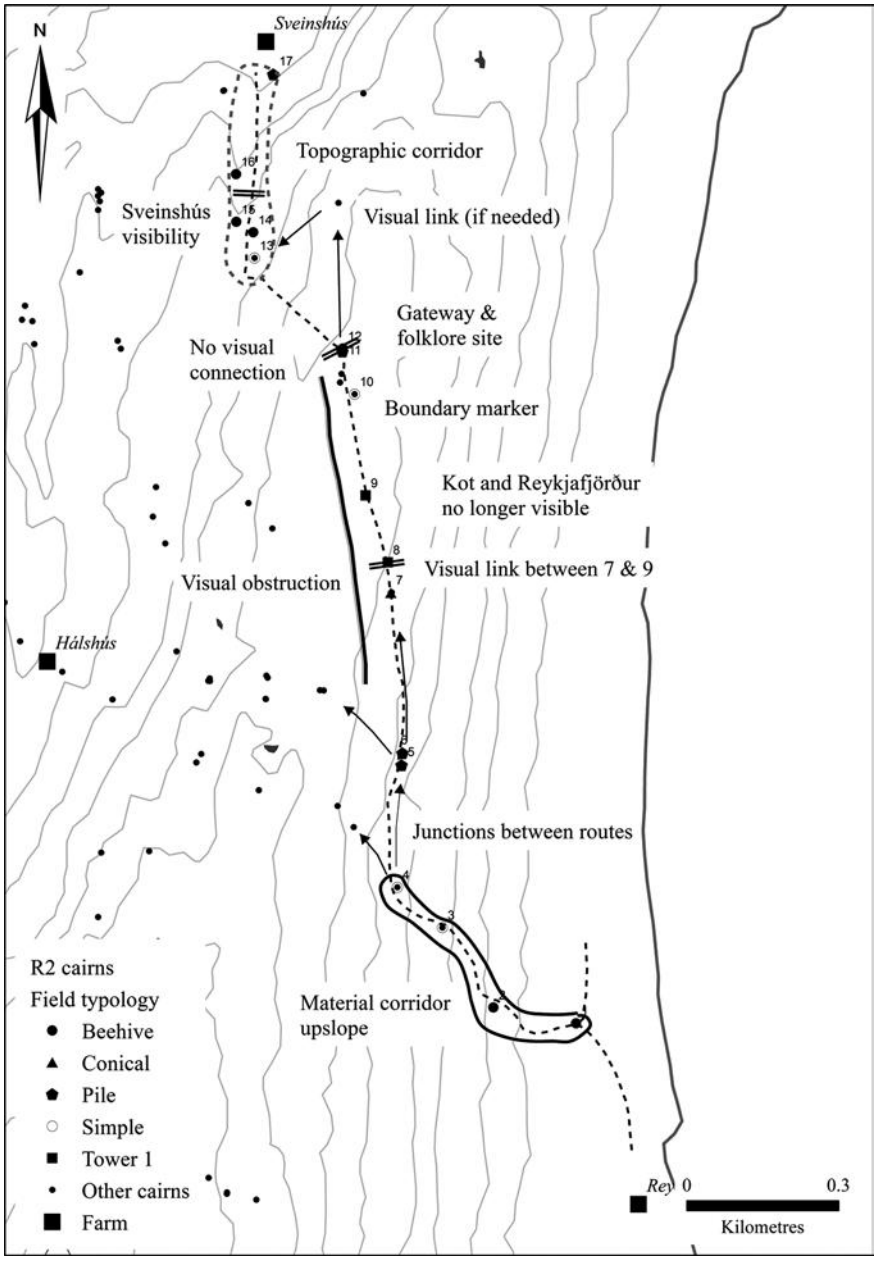

Figure 2.6 Route 2 – operational sequence and status of cairns

order to conceive the immaterial – like much of past movement – archaeology must try to understand it in material terms (c.f. earlier, Buchli 2010: 185).

Operational chains therefore are used to assign precise descriptions of movement practices through their use. Thus, material sites such as cairns that form broader coherent units such as route (assemblages, as it were), can then be used to compare different movements between various parts of a landscape. Such a perspective gives rise to a better representation of a landscape that was used and continues to be inhabited by people on-the-move, while giving a sound practical and theoretical basis for advancing a problem-orientated archaeological practice.

Another technique that has similar outcomes is rhythmanalysis. Rhythmanalysis has had limited exposure as a practical device for studying dynamic practices, but has had fairly comprehensive theoretical discussion (e.g. Lefebvre 2004, Mels 2004, Edensor 2010). The root of rhythm's theoretical discussion is derived from Gaston Bachelard's philosophy, inspired by Lucio Alberto Pinheiro dos Santos (1931). Bachelard suggested that rhythmicized living and thinking could be an alternation of activity and rest could lead to a cure for general depression and mental apathy (Bachelard 1936): 'a rhythmanalysis that would tend to reconcile and lighten the ambivalences that psychoanalysts find in the disturbed psyche' (Bachelard 1994: 65). Following and building on these ideas much later, Lefebvre (2004) suggested that an emerging science called *rhythmanalysis* could investigate the complex interactions of cyclical and linear rhythms from how bodies interact with everyday, temporal rhythms.

In the limited practical demonstration of rhythmanalysis, mainly in social sciences and geography, the focus has been directed toward the study of just the body, such as its circulatory system. However, the theoretical basis for rhythmanalysis makes it clear that the potential is co-joining the study of bodies *and* materials. For instances, the premise for Lefebvre was that 'everywhere where there is interaction between a place, a time, and an expenditure of energy, there is rhythm' (Lefebvre 2004: 15). The focus on this interaction has to a large extent been on the body (active) in its relation to (passive) space and its objects. Each body and inter-bodily space 'may be pictured as possessed of specific assets: the *material* (heredity, objects) which serve their starting point, and the *matériel* which they have available to them (behaviour patterns, conditioning – what are sometimes called behaviour patterns)' (Lefebvre 1991: 234). In advancing rhythmanalysis, and these practical, but general examples, Lefebvre used musicology, exploiting the triad of *melody* (sequence of notes in temporal succession) – *harmony* (relying on notes being played at the same time) – *rhythm* (the placement of notes and their relative lengths), uniting them into a trialectic, an approach that underpinned his dialectical, materialist philosophy in terms of synthesis (Lefebvre 1968). 'Music integrates the functions, the value of Rhythm … ' (Lefebvre 2004: 66), just as movement itself integrates the different relationships between material systems and moving bodies. Rhythm therefore has the ability to give an alternative to the mathematical models of calculation and measurement that were prevalent in other mechanisms that aimed to bring together space-time, such as time geography.

The paradox that Lefebvre left us with was that in order to study rhythm one must be placed outside of them: to be in rhythm is not to sense them (Lefebvre 2004: 27); to analyse rhythms 'one must get outside it' (Lefebvre 2004: 88) which may mean maintaining a material distanciation. Yet Lefebvre also advocated that to know rhythm one has to live in them. Thus, the contradiction lies in giving an analysis of rhythm enough distance so as to recognize it but without being too affected by its progression and losing its lived-in qualities. Thus, by its necessity rhythm is studied *both* from the interior (at the level of the body) so that one can 'listen' and perceive its exterior (from the collective or assemblage of moving bodies and materials). In this way, material systems and moving bodies remain *entangled*. Arguably, the emphasis on these recent studies derives from a systemic misunderstanding of Bachelard and Lefebvre that has focused on the interiority of rhythm as the only 'site' or centre of calculation. Whereas to fully account for rhythm in movement – as a means by which to explain past movement – the convergences of multiple rhythms and multi(ple)-sites is foregrounded.

How archaeology studies rhythm in the context of movement, whether from the perspective of Lefebvre, or more recent work by Edensor (2010), Mels (2004) and Ingold (2011), is still wide open. One study has however explored the notion of rhythm as a way of conceptualizing the relationship between humans and environments (Sturt 2006). Although applied to maritime and wetland areas, and in an altogether different period (Mesolithic to Bronze Age), the study flags the potential in viewing the human/environment relations dynamically through rhythmanalysis. The emphasis is not so much to do with movement *per se*, but as a way to overcome the tensions that exist in landscape archaeology between Cartesian, map-based approaches and phenomenological, experiential ones through the ideas associated with lived space and rhythm.

The disciplinary problem is one area that rhythm can help to overcome. Another is the actual rhythmic properties and their time-depth in a landscape inhabited by people. The central feature in rhythm and movement is connected with the merging of both time and space through principals of synchrony and synchorisy. As Leroi-Gourhan suggests rhythm is a means of 'domesticating' space-time, which creates a more humanized understanding (c.f. Leroi-Gourhan 1993: 313–4), as opposed to an abstract sense, of space and time which many archaeologies employ. And just as in movement, this is more than either measuring distance covered or the time taken to move but combining distance and time into a single entity: rhythm. Rhythm therefore extends movement from an abstract veneer, as something that happens without material effect, into a series of tangible movements that can be measured and compared. Most of these tangible aspects of rhythm are 'felt', but what I aim to do is to give them some kind of material form, to express rhythm's spatial and temporal compression by combining the material systems and the moving bodies into a single entity.

Representing these aspects of rhythm in a form that can be understood by others is challenging because of the difficulties of encoding the forces and the progression of spatio-temporal movement shown as landscape. Usually a

landscape is presented as a static image, but it would be better to represent its dynamic and moving qualities by showing the peripatetic and actual movements as an image through video (c.f. Witmore 2004). Assigning movement with its dynamic qualities that emerge from displacing space and time is one of the features that come from representation rhythm (Crang 2001: 206–7, c.f. Deleuze 1991). The utility of turning rhythm from a movement that is felt (interior) to something that is abstractly represented outside of the body (exterior) is for analytical purchase. This is also useful in so far as it helps find a means by which to align past materials with contemporary moving bodies, transgressing a major limitation for examining movement in archaeology; the opposite of that in other disciplines: a representation of movement that is all material without bodies.

Thus, the aim of rhythmanalysis, and its application in archaeology, is to demonstrate the extent to which movement can be examined independently its past moving bodies. In this respect historical enquiry, GIS and embodiment, and time geography can potentially become thoroughly entangled with one another. This leads to a tantalizing proposition, one that was alluded to with respect to operational chains. That *actual* movement in the past that helped to materialize movement in the landscape, and the *virtual* images of those movements that archaeologists reproduce from the material record, can begin to merge through the representation of movement as a *rhythmic signature*. The rhythmic signature therefore is a mix of the *actual* and *virtual* in which there is a transference between two sets of movements: between those that have become materialized in the past and those movements in the present. Aligning these past materialized movements with contemporary moving bodies produces a *potential actualized* movement, and relies on mapping two interdependent layers: the material system composed of sites, routes and landscapes that have been surveyed and interpreted; and the movements of archaeologists, recording the distances and times it takes to move along routes.

Cairns and landscape topography can be employed to realize this approach. Cairns arranged into well-defined routes, drawing on the collective knowledge of inhabiting the landscape for many weeks every year, gave the opportunity to experiment on different ways to document movement, based on the premise of merging the material remnants of past movement in cairns with those of the archaeologists moving along them. Several of the 85 routes that were interpreted in Vatnsfjörður's landscape were walked using a GPS tracking device that measured speed, direction and distance related to the movement of those individuals that were tracked. What this produced was a detailed, measured data set with which to relate human mobility to the routes that had been surveyed. The rhythmic quality associated with each route was therefore created by combining the actual data collected while moving, added to the spatial and material arrangements of the route, the cairn and the topography of the landscape, especially the angle of slope (generated from DTM using GIS).

Although route 3 only contained two cairns, it had a well-defined, hollowed track that ran from the farm of Vatnsfjörður to sheep houses that were old in the

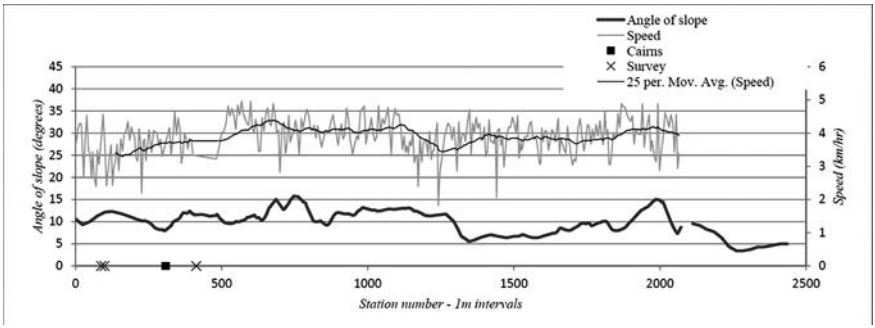

Figure 2.7 The rhythmic signature along route 3 showing angle of slope (real values), cairns (x2) and speed (km/hr) – without the stoppages i.e. 0 km/hr

late-nineteenth century. By examining aspects of the material – principally the topography, alongside the two cairns, and the speed of an archaeologist moving along the route from Vatnsfjörður to sheep houses, a strong correlation was demonstrated on the graph between the angle of slope and the moving average speed (Figure 2.7). In another example, using a similar technique of combining different facets of the temporal and spatial features onto an abstract graph, it is possible to examine further the transitional features associated with movement that can help to explain past movement practices. Along route 8, although a different archaeologist than the one moving along route 3, a similar alignment appears to be happening between the angle of slope and the speed of moving. Thus, in experimenting with tracking devices in order to determine the kind of relationship that a moving body has with a route, the cairns and the landscape, an actual model can be applied to the landscape and the routes so as to gain a better insight behind past choices being made in the construction of cairns and their placement in the landscape, and why certain parts of the landscape were used for routes and not others. Some of these questions can be speculated on by other means, but the rhythmanalysis establishes a sound empirical basis for such an interpretation that inevitably leads to reconsidering static and fixed remains such as archaeological sites and the landscape in a more dynamic, mobile way. Therefore, the material is itself constitutive of many aspects of past movement, but in order to get from there to here moving bodies have been used to ascertain the correct formula for unlocking this correlation, which may be different for other landscapes and archaeological sites. However, rhythmanalysis when used in this correlative way is like a *Rosetta stone of movement*. It enables archaeologists to translate a fixed, material property into a dynamic one.

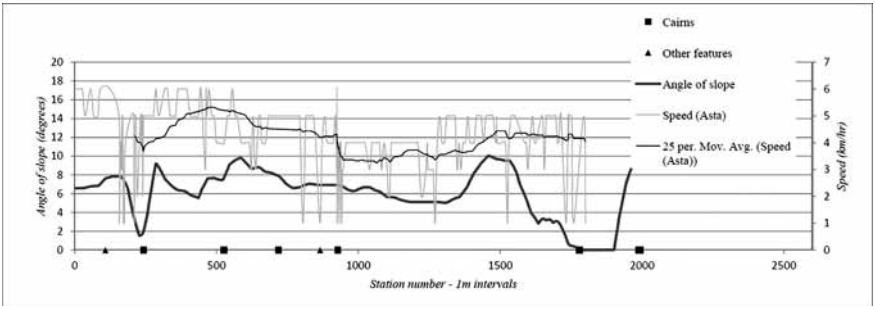

Figure 2.8 The rhythmic signature along route 8 showing angle of slope (real values), cairns, other features and speed from two different surveyors – without stoppages i.e. 0 km/hr

Some conclusions

In several steps, past movement has been articulated through operational chains and rhythmanalysis. The main objective has been to interrogate the form of past movement as an operation, its strategies and tactics as a material practice, and the role of mobile bodies in advancing an understanding about the inhabitation of landscape. The two tools that I have offered have approached the problem from two different directions that can be neatly summed up (though much reduced) in two statements. Operational chains explored the idea that *movement makes material*, in which understanding the operation of movement has allowed its internal logic, in the study of cairns, to be unravelled: *movement as a journey*. In contrast, Rhythmanalysis explored the notion that *material makes movement*, which produces a rhythmic reaction corresponding to the topography and positioning of the cairns in which the interior of movement is externalized, as it were, through a distanciation: *how* one moves during fieldwork has important consequences for the interpretative process, and presented movement as a conjunction between *body and landscape*. In their composition, both of these approaches have impressed the idea that in order to study movement there is a need to understand it not dialectically, in-between static materials and moving bodies, but rather through the flows in which these two become co-constituent in movement. Because in as much as we want to define movement as flow, it is also defined by its fixed, structural elements that have often continued to have resonance from the past into the present.

In taking these ideas forward from what has been a complicated argument to their logical conclusion, it is necessary to ask two further questions that must to some extent remain unanswered until more work is done. The first question is: what does studying past movement bring to archaeology? Answering this depends on the position one takes about the object and subject of study in archaeology. If the task before us is to study what remains from the past and why there is preservation of past movement in one place and not in another, then understanding the way in

which movement may have imbued materials into its project can be used to create an intellectual space for the examination of the structural efficacy of materials and their continued presence. An example that might help to answer this comes from archaeological survey and study of the repetitive reaffirmation of many routes in the same spatial location over the long-term. What this might suggest is that many contemporary movements have deep temporal relationships, say, across multiple generations of landscape's inhabitants. Simply knowing more about how people moved in the past also means getting to know what the conditions were for the continued use of material forms and behavioural mechanisms behind inhabiting the landscape.

The second question is: what can archaeology add to the mobility paradigm? I think one of the most interesting features of studying movement from an archaeological perspective is the work that goes into linking different temporalities together, such as the present material aspects of movement, over and above the absent human witnesses from the past, and the types of tools that are used to study these. Archaeology has worked hard on trying to understand the formation of its objects and subjects from a living system to an archaeological one (for more work that is influencing contemporary practices c.f. Schiffer 1972, 1985, Binford 1962, 1981, Barrett 1988, Patrik 1995, Hodder 1997, Lucas 2012), and this work is underwriting the approach taken here. Where it departs from the majority of these perspectives is on whether things stand-still, or if they do at all. Many contemporary practices in archaeology treat archaeology as static, as a so-called straight line: that as soon as a thing becomes buried, as it were, it stops moving. But this is far from the case (*cf.* Aldred 2014). Past objects continue to move in some form, perhaps much more slowly than when they were used more often or before when coupled with certain agents such as humans. As soon as objects come into contact again with humans they increase in their speed. Becoming 'archaeological' is a part of that speed: excavated materials moved around a site, packaged and labelled and processed, and reproduced through these practices; or cairns mobilized for an archaeological survey – translated and represented in new forms. Archaeology therefore is defined not by a simple flow which moves from a living system to a fossilized one, but by inchoate periods of mobility and dispersion operating along operational chains and rhythms, that move at different speeds.

If archaeology is to be defined by its materiality, then it is also defined by these fluctuating mobilities. And this notion of flow and variation in seemingly inert things can be added back into the mobilities paradigm by giving presence to the tensions that tend to be black-boxed: the pairing between fixed, static objects and mobile ones. Indeed, the Emerson quote at the start of this chapter can be extended further: 'every object is covered over by its hints' … *of past mobilities*, and archaeologists can reveal them.

References

Adey, P. 2010. *Mobility*. London: Routledge.

Aldred, O. 2014 *An Archaeology of Movement: A Methodological Study*. PhD thesis, Reykjavík: University of Iceland.

Aldred, O. and Sekedat, B. 2010. *Part 1 of Moving on to Mobility: Archaeological Ambulations on the Mobile World*. [Online: Archaeolog]. Available at: http://traumwerk.stanford.edu/archaeolog/2010/12/moving_on_to_mobility_archaeol.html [accessed: 15 December 2010].

Anthony, D.W. 1990. Migration in Archaeology: The Baby and the Bathwater. *American Anthropologist*, 92(4), 895914.

Bachelard, G. 1936. *Earth and Reveries of Will*. 2000 edition. Dallas: Dallas Institute Publications.

Bachelard, G. 1994. *The Poetics of Space*. Boston: Beacon Press.

Barrett, J. 1988. Fields of discourse: Reconstituting a social archaeology. *Critique of Anthropology*, 3(2), 5–16.

Barrett, J. 1994. *Fragments from Antiquity: An Archaeology of Social Life in Britain, 2900–1200 BC*. Oxford: Blackwell.

Binford, L.R. 1962. Archaeology as anthropology. *American Antiquity*, 28, 217–25.

Binford, L.R. 1978. *Nunamiut Ethnoarchaeology*. New York: Academic Press.

Binford, L.R. 1981. Behavioural archaeology and the 'Pompeii Premise'. *Journal of Anthropological Research*, 37, 195–208.

Bolender, D. and Aldred, O. 2013. A restless medieval? Archaeologies and saga-steads in the Viking Age North Atlantic. *Postmedieval*, 4, 136–49.

Buchli, V. 2010. Presencing the im-material, in *An Anthropology of Absence. Materializations of Transcedence and Loss*, edited by M. Bille, F. Hastrup and T.F. Soerensen. New York: Springer, 185–203.

Büscher, M., Urry, J. and Witchger, K. 2010. *Mobile Methods*. London: Routledge.

Childe, V.G. 1956. *Piecing Together the Past. The Interpretation of Archaeological Data*. New York: Praeger.

Coupaye, L. 2009. Ways of enchanting: Chaînes opératoires and yam cultivation in Nyamikum Village, Maprik, Papua New Guinea. *Journal of Material Culture*, 14(4), 433–58.

Crang, M. 2001. Rhythms of the city: Temporalised space and motion, in *Timespace Geographies of Temporality*, edited by J. May and N. Thrift. London: Routledge, 187–207.

Cresswell, R. 1976. Techniques et cultures. Les bases d'un programme de travail. *Techniques et Cultures*, 1, 1–16.

Cresswell, T. 2006. *On the Move: Mobility in the Modern Western World*. London: Routledge.

Deleuze, G. 1991. *Bergsonism*. New York: Zone Books.

Deleuze, G. and Guattari, F. 1988. *A Thousand Plateaus. Capitalism and Schizophrenia*. 2004 edition. London: Continuum.

Dobres, M.-A. 2000. *Technology and Social Agency: Outlining a Practice Framework for Archaeology*. Oxford: Blackwell Publishers.

Edensor, T. 2010. *Geographies of Rhythm: Nature, Place, Mobilities and Bodies*. Farnham: Ashgate.

Edgeworth, M. 2011. *Fluid Pasts: Archaeology of Flow*. London: Bloomsbury Academic.

Edmonds, M. 2006. Who said romance was dead? *Journal of Material Culture*, 11(1–2), 167–88.

Edvardsson, R. 2003. *Fornleifarannsókn í Vatnsfirði við Ísafjarðardjúp sumarið 2003*. Reykjavík: Fornleifastofnun Íslands.

Edvardsson, R. 2004. *Fornleifarannsókn í Vatnsfirði við Ísafjarðardjúp sumarið 2004*. Reykjavík: Fornleifastofnun Íslands.

Edvardsson, R. and Mcgovern, T. 2005. Archaeological excavations at Vatnsfjörður 2003–04. *Archaeologia Islandica*, 4, 16–30.

Emerson, R.W. 1903. *The Complete Works*. Boston: Houghton Millflin.

Friðriksson, A., Tulinius, T.H. and Guðmundsson, G.E. 2005. *Fornleifarannsóknir/ Fieldwork at Vatnsfjörður, NW-Iceland*. Reykjavík: Fornleifastofnun Íslands.

Geertz, C. 1973. *The Interpretation of Cultures: Selected Essays*. New York: Basic Books.

Grønlie, S. 2006. Íslendigabók – *Kristin saga – The Book of Icelanders – The Story of the Converson*. London: Viking Society for Northern Research.

Hägerstrand, T. 1970. What about people in regional science. *Regional Science Association Papers*, 24, 7–21.

Hägerstrand, T. and Pred, A. 1981. *Space and Time in Geography: Essays Dedicated to Torsten Hägerstrand*. Lund: CWK Gleerup.

Haggert, P. and Chorley, R. 1969. *Network Analysis in Geography*. New York: St. Martin's Press.

Hermann, P.L. and Edwards, P. 1972. *The Book of Settlements; Landnámabók*. Winnipeg: University of Manitoba.

Hodder, I. 1997. Always momentary, fluid and flexible: Towards a reflexive excavation methodology. *Antiquity*, 71, 691–700.

Ingold, T. 2011. *Being Alive: Essays on Movement, Knowledge and Description*. London: Routledge.

Ingold, T. and Vergunst, J.L. 2008. *Ways of Walking: Ethnography and Practice on Foot*. Farnham: Ashgate.

Leach, E. 1973. Concluding address, in *The Explanation of Cultural Change*, edited by C. Renfrew. London: Duckworth, 761–71.

Lefebvre, H. 1968. *Dialectical Materialism*. London: Jonathan Cape.

Lefebvre, H. 1991. *The Production of Space.* Oxford: Basil Blackwell.

Lefebvre, H. 2004. *Rhythmanalysis: Space, Time and Everyday Life*. London: Continuum.

Lemonnier, P. 1986. The study of material culture today: Toward an anthropology of technical systems. *Journal of Anthropological Archaeology,* 5(2), 147–86.

Lemonnier, P. 1993. *Technological Choices: Transformation in Material Cultures since the Neolithic*. London: Routledge.

Lenntorp, B. 1976. *Paths in Space-time Environments: A Timegeographic Study of Movement Possibilities of Individuals*. Lund: Royal University of Lund, Dept. of Geography.

Leroi-Gourhan, A. 1993. *Gesture and Speech*. Cambridge, Mass.: MIT Press.

Lucas, G. 2001. *Critical Approaches to Fieldwork: Contemporary and Historical Archaeological Practice*. London: Routledge.

Lucas, G. 2008. Time and archaeological event. *Cambridge Archaeological Journal*, 18(1), 59–65.

Lucas, G. 2012. *Understanding the Archaeological Record*. Cambridge: Cambridge University Press.

Macfarlane, R. 2012. *The Old Ways*. London: Hamish Hamilton.

Mauss, M. 1979. *Body Techniques. Sociology and Psychology*. London: Routledge.

Mels, T. 2004. *Reanimating Places: A Geography of Rhythms*. Farnham: Ashgate.

Milek, K. 2010. *Vatnsfjörður 2009. Interim Reports*. Reykjavík: Fornleifastofnun Íslands.

Milek, K. 2011. *Vatnsfjörður 2010. Interim Reports*. Reykjavík: Fornleifastofnun Íslands.

Mlekuž, D. 2010. Time Geography, GIS and Archaeology, in *Fusion of Cultures. Abstracts from the 38th Conference on Computer Applications and Quantitative Methods in Archaeology*, edited by J.F. Melero, P. Cano, and J. Revelles. Granada: University of Granada/CAA International, 1–7.

Naji, M. and Douny, L. 2009. Editorial. *Journal of Material Culture*, 14(4), 411–32.

Olsen, B. 2010. *In Defense of Things. Archaeology and the Ontology of Objects*. Walnutt Creek: AltaMira Press.

Patrik, L. 1985. Is there an archaeological record? *Advances in Archaeological Method and Theory*, 8, 27–62.

Pearson, M. and Thomas, J. 1994. Theatre/Archaeology. *The Drama Review*, 38(4), 133–61.

Pinheiro Dos Santos, L. A. 1931. *La Rhythmanalyse*. Rio de Janeiro: Société de Psychologie et de Philosophie.

Pred, A. 1977. *City Systems in Advanced Economies: Past Growth, Present Processes, and Future Development Options*. New York: Wiley.

Pred, A. 1986. *Place, Practice and Structure: Social and Spatial Transformation in Southern Sweden: 1750–1850*. Cambridge: Polity.

Schiffer, M. 1972. Archaeological context and systemic context. *American Antiquity*, 37(2), 156–65.

Schiffer, M. 1985. Is there a 'Pompeii Premise' in archaeology? *Journal of Anthropological Research*, 41, 18–41.

Shanks, M. 2012. *The Archaeological Imagination*. Walnut Creek: Left Coast Press.

Sheller, M. and Urry, J. 2006. The new mobilities paradigm. *Environment and Planning A*, 38(2), 207–26.

Snead, J.E., Erickson, C.L. and Darling, J.A. 2009. *Landscapes of Movement: Trails, Paths, and Roads in Anthropological Perspective*. Philadelphia: University of Pennsylvania Museum of Archaeology and Anthropology.

Sturt, F. 2006. Local knowledge is required: A rhythmanalytical approach to the late Mesolithic and early Neolithic of the East Anglian Fenland, UK. *Journal of Maritime Archaeology*, 1(2), 119–39.

Tilley, C. 1994. *A Phenomenology of Landscape: Places, Paths, and Monuments*. Oxford: Berg.

Trombold, C.D. 1991. *Ancient Road Networks and Settlement Hierarchies in the New World*. Cambridge: Cambridge University Press.

Tulinius, T.H. 2005. The Westfjords. *Archaeologia Islandica*, 4, 9–15.

Warnier, J.-P. 2001. A praxeological approach to subjectivation in a material world. *Journal of Material Culture*, 6(1), 5–24.

Warnier, J.-P. 2009. Technology as efficacious action on objects … and subjects. *Journal of Material Culture*, 14(4), 459–70.

Webmoor, T. and Witmore, C. 2008. Things are us! A commentary on human/things relations under the banner of a social archaeology. *Norwegian Archaeological Review*, 41(1), 53–70.

Witmore, C. 2004. Four archaeological engagements with place: Mediating bodily experience through peripatetic video. *Visual Anthropology Review*, 20(2), 57–71.

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Chapter 3

Enmeshments of Shifting Landscapes and Embodied Movements of People and Animals

Matt Edgeworth

Introduction

In thinking of people or animal movements across and through landscapes, it often happens that landscapes themselves come to be conceived of by default as static backdrops to all that activity. In perceiving movement of people or other living beings we may sometimes inadvertently 'freeze' the landscape. People or animals move, but the landscape stays where it is. Even when shifts of terrestrial surfaces and patterns are taken into account, it is easy to see these as mainly driven by human forces or as the effects of human agency, with no comparable forces seen to be operating in the other direction.

In some of the other chapters in this book, however, another scenario presents itself. In the case of boats, for example (Dunkley, Chapter 10) people move around on a landscape which is itself moving. The landscape has flows of materials going through it – in the form of rivers or streams for example – and people are interacting with these, moving with or against material currents. Such forces, though shaped and modified artificially, are not primarily human in origin, yet need to be taken into account all the same. Thus on a boat there is no such thing as an unmoving ground on which movement takes place, for the water on which the boat moves is moving too. Not only that, but the riverbed and the banks and indeed the whole floodplain are moving as well, all at various speeds and in different ways – some noticeable by the human eye over a short time, some experienced over the space of a few days, others observable only over the course of months or years or decades.

My suggestion here is that all landscapes are like that to a certain extent, in the sense of being comprised in parts of different flows – flows of people and animals, yes, but also flows of water and other materials, moving at different scales and rhythms yet interacting and enmeshed with each other all the same. The aim of this chapter is to explore some of those enmeshments. During the following discussion I shall be exploring connections between archaeological studies of landscapes and Tim Ingold's vision of the world as a kind of meshwork (Ingold 2007a, 2008a), but it is important to make a fundamental point about method first. The idea is not to accord any one thinker's work primacy and then to configure material evidence

within that theoretical framework (in the manner of so much archaeological theory today), but rather to try and pick up on some of the material flows in archaeological landscapes and follow them along, taking our research directions and trajectories from them, instead of from applied systems of ideas. That is not to claim that interpretation of landscapes can ever be theory-neutral; it is merely to assert the power of materials to lead ideas as well as the other way round. As it happens, some of the material strands that are followed fit quite neatly with Ingold's notion of intermeshing lines of movement (tracks, flows, currents, paths), and it will be useful to weave some of his argument into the woof and warp of this chapter.

I shall essentially be looking at two types of lines of flow:

1. roads or droveways along which movements of people with all their vehicles and animals and goods are channelled.
2. the rivers which these paths of movement frequently have to cross.

As will become clear, crossing-points like bridges and fords are key places in landscapes. As the places or nodes where lines of movement intermesh, they have special importance for landscape analysis. Importantly, however, these should not necessarily be regarded as static points, facilitating movement but not moving themselves. On the contrary, crossing-points can themselves be mobile features of a landscape, as the two case studies further on in this chapter will show.

Crossing-places

Heidegger famously remarked that bridges do more than simply cross a river and make a connection between its banks. 'The bridge', he pointed out, 'gathers the earth as landscape around a stream' reconfiguring the land and even the sky in a new way. This of course is true, but he went on to say that the gathering location never precedes the bridge. 'The bridge does not come first to a location and stand in it: rather, a location comes into existence only by virtue of the bridge' (Heidegger 1971: 150–70). We know what he means, but as archaeologists we suspect there might be something Heidegger is overlooking here. From an archaeological point of view, bridges are often only the latest phase of a long tradition of river crossing at or near that place. In many cases bridges were built on or near the location of pre-existing fords. That was certainly the case with the medieval bridge at Heidelberg, said to be the bridge that inspired Heidegger to write the well-known passage. As with Wallingford Bridge on the River Thames (Edgeworth and Christie 2011), the ford came first, and was probably in use from early prehistory. The bridge, venerable though it now is, came later (though there may have been a period when both were in use together). In this sense fords can generally be taken to be more primordial than bridges. Partly for this reason, and partly because they have not received the same attention as bridges in the literature, fords are given primacy in this chapter.

Whereas a bridge crosses the flow of water, it is worth noting that in the case of fords it is the other way round. Here the water crosses the path or track. In order to get from one side to the other, you have to actually physically immerse yourself (or the animal or vehicle that is taking you across) in the flowing liquid. It is arguably a more embodied kind of movement than that of crossing a bridge, engaging the body in a multi-sensory mode of engagement with the landscape. It is definitely a more materially embedded kind of movement.

A ford gathers the landscape around the stream in the same way as a bridge does – though in a more fluid, not so rigid and less visually imposing manner, requiring little or no investment in infrastructure. Like a bridge, it pulls in tracks and their human and animal traffic from many different directions to cross the river at that point, like so many threads grasped tightly in the hand. But it is not just at the ford itself that the gathering of landscape takes place. Patterns of fields, houses, farms, and so on come to be configured in relation to the roads that radiate into and out of the crossing-place. In many cases, then, the landscape has been 'gathered', in Heidegger's sense of the word, around fords long before a bridge was built to form a more solid and more visual connection between the two banks.

Once 'gathered', fords – like bridges – may become important strategically and symbolically. As dangerous, liminal places, they can acquire ritual and religious significance. As places to cross the river boundary from one territory to another, they may become meeting-places or assembly points. Settlements and towns often get built next to fords, which later get replaced by bridges, fixing the routes leading up to it into a more static configuration. In Anglo-Saxon England, fords were much more common than they are now, with rivers generally wider and shallower. Of about 520 settlements named after river crossings in the Domesday Book of 1086, 480 are named after fords and only 40 after bridges (Rackham 1994: 122). Wallingford on the River Thames or Bedford on the River Great Ouse are typical examples. Some towns like Oxford or Shefford (a small town in Bedfordshire) also contain elements in their place-names that indicate the flows of animals once driven into and through the flow of water (herds of oxen and sheep in these instances).

But fords were special places even when situated far from any settlement, no less important for constituting a kind of no-man's land betwixt-and-between territories, neither in one place nor the other. The Anglo-Saxon Chronicle records that when King Edward the Elder met the King of the Danes of East Anglia and Northumbria in 906 to arrange a truce, the place chosen for the meeting was Yttingaford, where the ancient Thiodweg (weg = way) crossed the River Ousel on the boundary between Saxon and Danish territories (Gurney 1920). The image of two leaders on horseback parleying terms in the middle of the river powerfully conveys the sense in which material, strategic, symbolic and political currents were all interwoven.

The interesting thing about fords from the point of view of a mobilities paradigm is that as well as facilitating movement across the river they themselves move around and rarely stay in one place. Unlike solid structures fixed in position,

such as bridges, they are part of the changing geomorphology of the river. As rivers meander from side to side in snake-like fashion, there is corresponding up-and-down movement of the riverbed. Series of alternate shallows and pools shift slowly downstream in wave-like patterns. Fords shift position because they are part of this physical process of movement and change, as well as points or nodes on cultural, political and commercial communication networks.

Another reason for the movement of fords is that they are subject to human interventions in patterns of flow. Fords can be dredged or physically taken out or radically influenced by interventions in river flow both upstream and downstream. Place a weir or other kind of dam across the river a distance downstream, for instance, and it will deepen the water over the ford, drowning it or making it difficult to use. Place a weir some distance upstream and it may create scouring and erosion of the riverbed or dangerous currents that impede crossing. The building of weirs may itself have created conditions that led to abandonment of fords and building of bridges on nearby stretches of the same rivers (Cooper 2006).

For all the reasons mentioned above, and many more, a ford may move – and when it moves it takes with it the configuration of roads and tracks that were formerly gathered into it. A typical scenario is that a ford gets abandoned, and (unless replaced by a ferry or bridge) a new crossing-place some distance away often gets used in its stead. Roads that headed for the old ford have to take another route to the new crossing, bringing about a corresponding wrenching and warping of the surrounding landscape. Farms and villages hitherto on the old route now get left high and dry as the road deserts them. Configurations of fields and settlements may then get realigned along the new roads rather than the old.

This wrenching and warping process was not uncommon and wherever it took place a characteristic pattern was left behind in the landscape. It is a pattern that holds great possibilities for archaeologists, for many of the interesting and significant sites can be found on the old fording-places, or indeed on the former roads or droveways that once headed in towards the fords that are long since abandoned. For example, a newly discovered site which might be the lost Viking fort of Tempsford was found at a place where an old but significant routeway – possibly a former course of the Great North Road – once crossed the River Great Ouse (Edgeworth 2008a). The ford in this case was deliberately removed in the early post-medieval period: the use of ploughs drawn by oxen to scour the riverbed and thus deepen the channel is documented in records of early navigation works. The road leading up to the ford went out of use, but its former course can be reconstructed through diligent fieldwork and mapwork. The general method can be applied more widely. Find the old roads, find the former channels of the old watercourses, follow them along, find the places where they crossed, and you are likely to discover significant sites along the way.

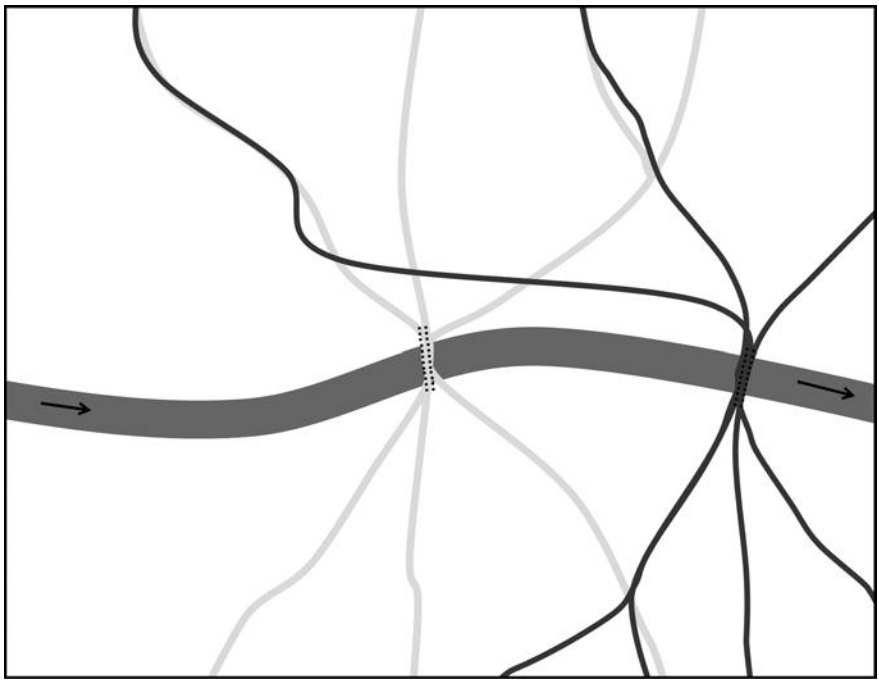

Figure 3.1 Schematic drawing of the wrenching and warping of lines of flow. Lighter lines show the pattern of roads approaching the old river crossing, vestiges of which may survive as relict features hidden in a landscape or townscape. Darker lines show the new river crossing as a re-gathering of old routes

But it is not the sites, however remarkable, that are crucial to the argument in this chapter. In looking at crossings of roads and rivers the possibility arises of moving beyond mere sites to perceive something of the strands and flows that formed connections between them – the shifting meshwork (to borrow Ingold's term) within which they were once suspended.

Case study 1

The small town of Biggleswade on the River Ivel in mid-Bedfordshire is chosen for this case-study partly because its name encapsulates the very immersion in and through water that is so characteristic of fords. Biggleswade derives from the Old English Bicca's Wade, the second element of which is a synonym for ford, with emphasis here on the word as a verb rather than as a noun. One does not so much cross a river at a wade: rather one wades across the river. Instead of a fixed

place it is an action or journey undertaken, and as such the term implies movement through space, against the resistance of flowing materials.

The wade or ford that gave the town its name has long since fallen out of use, to be replaced in medieval times by a bridge some distance out of town. When the Extensive Urban Survey of Biggleswade was conducted (Albion Archaeology 2003), the location of the original crossing-point was still a matter of speculation. However, work carried out by the Cambridge Archaeological Unit revealed a previously unknown broad droveway extending for several kilometres across the landscape and heading straight towards Biggleswade marketplace on the other side of the river (Mortimer and McFadyen 1999: 48–59). It is surmised that the droveway – a linear pasture as well as a track for animal movement – facilitated transhumance of large herds of sheep, cattle and horses between the lowland river valley and the upland Greensand Ridge, into and out of Bicca's Wade (Figures 3.1 and 3.2).

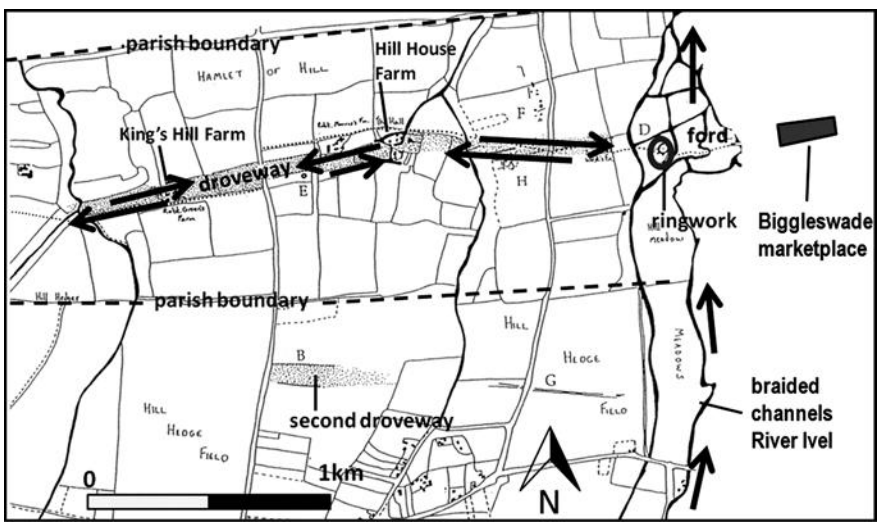

Figure 3.2 Newly discovered broad droveway heading (past ringwork) straight for Biggleswade marketplace on other side of river, indicating position of ford

Source: Adapted from Mortimer and McFadyen 1999: 58.

The newly discovered droveway, thought to be of middle Saxon date, comprises one section of a former corridor of movement: the trapezoidal marketplace (now understood to be an original feature of the developing town) comprises another. They are both part of the same broad pathway. It is a simple deduction to make that the place where the corridor crossed the river (which in early medieval times is thought to have consisted of multiple channels rather than the single canalised

channel of today) can be taken to be the location of the old ford or wade, on one side of which the town was located. The ford is not however an incidental element in the story. It is actually the key part of the archaeological landscape, a node in a shifting meshwork that was still in the process of formation, where strands of animal and human movement (e.g. the droveway) intermeshed with strands of flowing materials (e.g. the river).

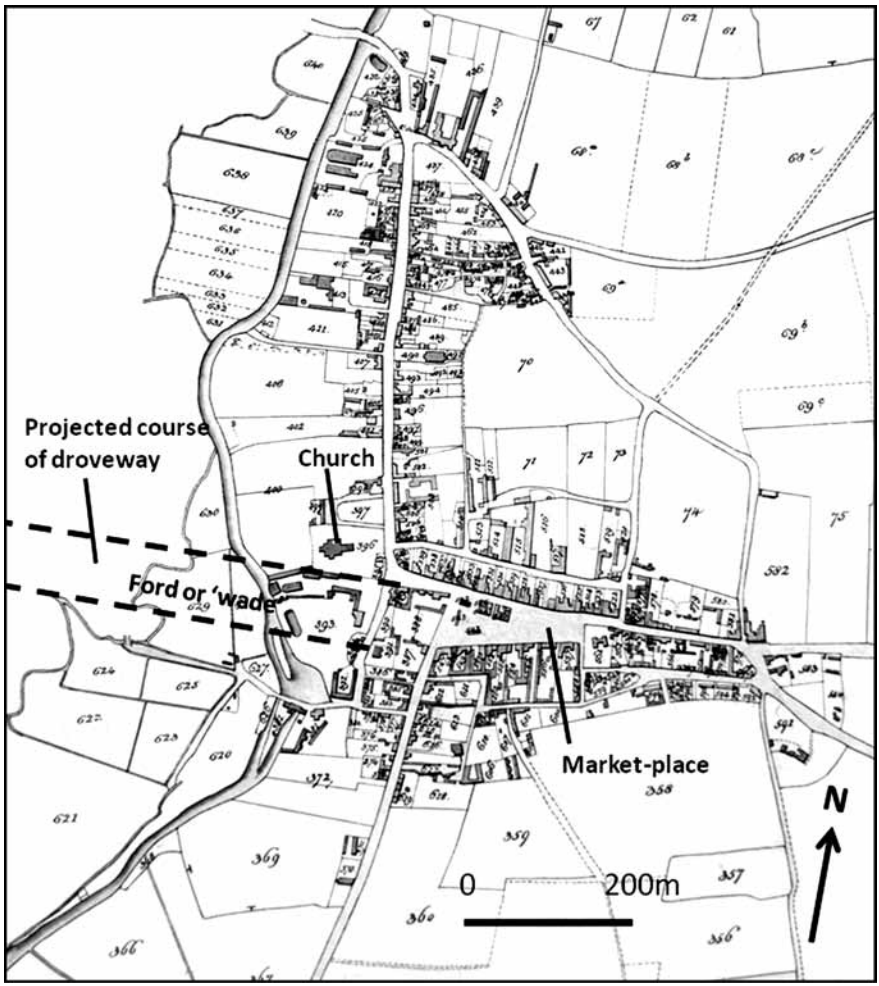

Figure 3.3 Former droveway and ford in relation to marketplace and other surviving townscape features. At the top of the picture is the medieval bridge which replaced the earlier ford (1838 tithe map of Biggleswade)

Our understanding of the origins and early history of the town is completely transformed by the idea that it drew much of its early potential for growth from being located on such a meshwork node. The discovery of the droveway and the realisation that the marketplace is directly on its projected continuation – not to mention the revelation about the location of the ford – changes everything. A fundamental pattern of intermeshing flows now underlies a new interpretation of town development. Flows of energy, materials, ideas, goods, news, and many different kinds of traffic ran into and out of the town along two main arteries of movement – droveway and river. In terms of town layout, these formed the principal axes around which the later town developed. Long after the droveway went out of use, the ford forgotten, the marketplace retained and preserved its linear shape, breadth and orientation. Most of the significant features of the town, such as the church, are located along this axis.

Elsewhere I have discussed a unique site now located on the other side of the river from the town but formerly on a gravel island between two channels. Conventionally classified as a ringwork or castle, for which it admittedly bears some superficial resemblance, an unusual pattern of segmentation within the supposed ditches (visible on aerial photos) actually makes it nothing at all like those classes of monument. I will not deal with it any further here, except to say that this is exactly the kind of site that can seem quite ordinary if dealt with as an isolated monument irrespective of geographical and archaeological context, but whose interpretation can be transformed once it is realised that it is located on a major crossing point of intermeshing paths of movement, deriving its swirling form and function in part from the enmeshment of animal, human and material flows (Edgeworth 2008b, 2011: 121–7).

The focus of this chapter, however, is not so much on individual sites but rather on the wrenching and warping of the landscape that can occur when river-crossings, for whatever reason, go out of use or are changed. This is what happened at Biggleswade at some point in the medieval period. A stone bridge was built across the River Ivel some distance to the north of the historic core of the town – an event usually dated to the twelfth century. Whether the abandonment of the ford prompted the building of a bridge, or whether the building of the bridge led to the abandonment of the ford, it is not possible to say. Perhaps there was a period during which both the ford and bridge were used concurrently, possibly for different kinds of traffic. At any rate much traffic that formerly crossed at the ford now headed for the bridge instead. New roads came into use and old ones were abandoned. Like so many threads pulled together in the hand and carried from one place to another, there was a re-gathering of strands of movement. The landscape, conceived of here as a kind of meshwork, underwent a reconfiguration around a new node or crossing-point of intermeshing flows.

In the example above there were two principal sets of forces enmeshed with each other, bringing about the change in location of the river-crossing. Firstly there were the political, economic and social factors which went some way towards determining the routes people (and their herds of livestock) took through

the landscape, and therefore the location of river crossings. Secondly there was the changing nature of the river itself, making some places favourable for crossing and others not, putting physical constraints on what was possible. The gradual transformation of the River Ivel from a multi-channelled stream into a single embanked channel, entailing the deepening and narrowing of the flow of water, inevitably made fording more difficult Such changes, as argued elsewhere (Edgeworth 2011, Lewin 2010) were themselves the result of entanglement of cultural and natural forces – processes of geomorphology and hydrology mixed with the artificial processes of modification of river flow in connection with navigation works, agricultural practices and other activities.

To these we can add a third set of factors enmeshed with the others – the forces of erosion and powers of attrition presented by the flow of countless animal bodies along a single route over hundreds of years, wearing away river bank and riverbed. When Daniel Defoe visited Biggleswade in 1724 the town was still an important stop on droving routes. He noted that 'droves of cattle in winter made road repair difficult' (Defoe 1742), thus pointing to the great capacity of livestock to wear away surfaces. A 'river' of cattle can cause erosion just as surely as a river of water. Put these together at a crossing-point and you have a veritable enmeshment of human, animal and geomorphological forces. It is likely that the ford was partially worn away, deepened, and eventually made unusable by the very passage of animals driven across the river.

Case study 2

I draw this second example from a recently published monograph by Susan Ripper and Lyndon Cooper, which describes the archaeological discovery of a series of bridges in a former river channel at Hemington on the River Trent (Ripper and Cooper 2009). An important north-south road called the King's Highway crossed the braided channels of the river here in medieval times. In the following account I draw heavily from Ripper and Cooper's report, building on the interpretations of the authors but also adding my own slant on the detailed archaeological evidence presented therein.

No visible trace of a bridge survives above ground, and there are no historical records of a bridge at this location either, so it was a surprise when excavators came across structural remains of the series of bridges buried within waterlogged gravel deposits. All were short-lived, and each was of different design from the others. The earliest, dated from the eleventh – twelfth centuries, was a trestle bridge built on timber caissons filled with sandstone blocks to make pier bases. Destroyed by flooding, this was replaced by a second bridge a little further upstream supported by pile-driven posts. This too was destroyed by floods and replaced by a third bridge – a timber walkway supported by masonry piers – in the mid thirteenth century. It lasted until the early fourteenth century. The destruction of the third bridge by floods marked the end of the structure for good. The river itself changed

course, abandoning its old channel for a new one, rendering obsolete the very idea of a bridge at that point. As a consequence the river-crossing too was abandoned and traffic turned to an alternative crossing-place about a mile away, taking the road with it (this paragraph is a summary of information from Cooper 2003, Ripper and Cooper 2009).

The material evidence of the bridges testifies to a wrestle that was taking place between people and forces of flow over the course of several centuries. The building of the bridge was not just a gathering of earth and sky or a connection between its banks in Heidegger's somewhat abstract aesthetic and philosophical sense, there was also a fundamental and elemental struggle going on with the flowing water that was pushing against and actively resisting the bridging project. Study of gravel sediments adjacent to bridge piers revealed deep scour holes where swirling water had undermined the piers, demonstrating the destructive action of the river on bridge foundations (Brown 2009). Conversely, changes in methods of bridge construction evident in designs of successive structures showed how bridge-builders responded to the challenges posed by the current. One strategy was to oppose the current with heavy structures that resisted flow (the first and third bridges): another to present as little resistance to flow as possible (the second bridge). From the archaeological evidence a compelling story of a physical struggle between disparate forces, human and non-human, sometimes opposing and sometimes confluent, emerges.

Measures were also taken to keep the river in its channel and prevent migration to another channel, by construction of stone structures off-setting and diverting the current at places where the riverbank was especially vulnerable to erosion (Cooper 2003). It must have been an ever-present anxiety for those who invested time, energy and money in building and maintaining the bridge that if the river channel changed course it would be left high and dry, with traffic forced to take alternate routes, thereby wrenching and warping the political and administrative landscape along with the physical one. As Courtney (2009) makes clear in his detailed analysis, this was a political as well as a material struggle. But all attempts to halt the process of river avulsion, successful over relatively short periods, ultimately failed.

What is really important here is to admit the somewhat wild forces of flow into the realm of archaeological and anthropological interpretation – to acknowledge that human actions and mobilities are enmeshed with the actions and mobilities of flowing materials. Relevant here are the hybrid geographies of human and non-human suggested by Sarah Whatmore (2002) and the symmetrical archaeological approach outlined by Christopher Witmore and Timothy Webmoor (2008). Evidence of the bridges and associated sediments at Hemington testifies to the enmeshment of human and non-human, social and material, politics and things. It makes us realise the enormous effort expended by people in trying to keep moving landscape features like rivers in place, to stop them moving around, to fix them in given positions. Such effort must have been entailed to some extent in all bridge-

building, characterised in this chapter as the imposition of a fixed structure on a shifting landscape.

The numerous other structures discovered in the former river channel in the vicinity of the three bridges, such as the two stone dams and the many fishtraps described by Clay and Salisbury (1990), reveal that the river at Hemington in medieval times was a veritable 'taskscape' (Ingold 1993) – though in this case located not just on land but in flowing water too. It was a taskscape immersed in flow, with flow fully integrated into all its structures, designs, actions and projects. In his important discussion of taskscapes, Ingold is right not to restrict the concept solely to the realm of interrelated human activities, or even to human-animal working relationships. Rather than take such an unsymmetrical view – skewed in favour of the mobilities and agencies of living creatures at the expense of the mobilities and agencies of non-living but nevertheless vibrant material things – Ingold recognises that taskscapes include within their relational structures actions of winds, tides, rain, and other inanimate energies and processes. In the context of this discussion, the gravity-driven flow of water in rivers and streams and more artificial waterways can be readily acknowledged as one of the energies of the world most directly engaged with and wrestled with by human beings. In many instances, as at Hemington, 'taskscapes' are also 'flowscapes' (Edgeworth 2011, 83–106).

Conclusion

It was suggested at the start of this chapter that the study of past mobilities in relation to archaeological landscapes tends to be unsymmetrical. Landscape can easily be seen as a static backdrop to human activity – the unmoving stage or screen on which mobilities are visualised and understood. What this chapter has tried to show is that there are material flows running through the landscape that are deeply enmeshed (in the sense of crossing over and under at key points of intersection) with the movements of human and animals. Archaeology can play a key role in bringing these material enmeshments to the fore, bringing greater symmetry to discussions on past and present mobilities.

Both case-studies focused on crossing-points which, due partly to geomorphological and partly to social and economic factors, moved from one place in the landscape to another. These shifts entailed associated movements of roads that used the crossings, and traffic using the roads. Such examples imply a landscape topology somewhat more fluid and dynamic even than Tim Ingold's meshwork. Ingold made the important distinction between a network and a meshwork, which is fully concurred with here. He spoke of 'a field not of connectable points but of interwoven lines, not a network but a meshwork' (Ingold 2008b: 1805). This is useful, at least as far as it goes. But the metaphor of the meshwork, as something created through human agency rather than through its own internal powers of growth and change, can sometimes lead us back to the unsymmetrical view of mobility discussed earlier, privileging human agency over

other material forces and flows active in the environment. The interwoven canes of a basket are solid things that, once plaited into an overall structure, retain their position and hold other canes in place. Though pliable, the mesh thus conceived is still resistant to radical changes in structure.

Here we need to go a step further than Ingold in theorising a somewhat more vibrant meshwork. By more vibrant I mean that lines of the mesh (and points of intersection) can themselves move (as well as be moved) in addition to being lines along which movement takes place – rather as a river may move in the lateral direction of its meanders as well as in the direction of flow. Imagine for example a meshwork made of living branches woven together, still subject to internal growth as well as forces operating on it from outside. In this revised view, slightly modifying the valuable metaphor of the meshwork, it is possible to conceive of parts of the meshwork being radically reconfigured in new patterns, through the operation of both internal and external forces. Strands and flows and lines that make up the mesh can wrench themselves/be physically wrenched out of their formerly stable positions towards new gathering points, in temporal processes that lead to more complex and dynamic forms of enmeshment.

References

Albion Archaeology 2003. *Extensive Urban Survey for Bedfordshire: Biggleswade Archaeological Assessment*. Bedford: Albion Archaeology (Report 2000/27).

Brown, A. 2009. The geomorphology and environment of the Hemington reach, in *The Hemington Bridges: The Excavation of Three Medieval Bridges at Hemington Quarry, Near Castle Donington, Leicester*, edited by S. Ripper and L.P. Cooper. Leicester: University of Leicester Archaeology Monographs, 142–73.

Clay, P. and Salisbury, C.R. 1990. A Norman mill dam and other sites at Hemington Fields, Castle Donington, Leicestershire. *Archaeological Journal*, 147, 276–307.

Cooper, A. 2006. *Bridges and Power in Medieval England, 700–1400*. Woodbridge: Boydell Press.

Cooper, L.P. 2003. Hemington Quarry, Castle Donington, Leicestershire, UK: A decade beneath the alluvium in the confluence zone, in *Alluvial Archaeology in Europe*, edited by A.J. Howard, M.G. Macklin and D.G. Passmore. Lisse: Swets and Zeitlinger, 27–41.

Courtney, P. 2009. Crossing the Trent: The Hemington bridges in local and regional context, in *The Hemington Bridges: The Excavation of Three Medieval Bridges at Hemington Quarry, Near Castle Donington, Leicester*, edited by S. Ripper and L.P. Cooper. Leicester: University of Leicester Archaeology Monographs, 174–220.

Defoe, D. 1742. *A Tour Thro' the Whole Island of Great Britain, Divided into Circuits or Journies*. 1927 edition. London: JM Dent and Co.

Edgeworth, M. 2008a. The Tempsford Project: An interim report. *South Midlands Archaeology*, 38, 8–16.

Edgeworth, M. 2008b. Linking urban townscape with rural landscape: Evidence of animal transhumance in the River Ivel Valley, Bedfordshire. *Medieval Settlement Research*, 23, 22–7.

Edgeworth, M. 2011. *Fluid Pasts: Archaeology of Flow*. London: Bloomsbury Academic.

Edgeworth, M. and Christie, N. 2011. An archaeology of crossing-places: The bridge and ford at Wallingford on the River Thames, in *Archäologie der Brücken: Vorgeschichte, Antike, Mittelalter, Neuzeit/Archaeology of Bridges. Prehistory, Antiquity, Middle Ages, Modern Era*, edited by M. Prell. Regensburg: Pustet Friedrich Kg, 232–9.

Gurney, F.G. 1920. Yttingaford and the tenth-century bounds of Chalgrave and Linslade. *Bedfordshire Historical Record Society*, 5, 175 (note 25).

Heidegger, M. 1971. Building, dwelling, thinking, in M. Heidegger *Poetry, Language, Thought*. Trans. Albert Hofstadter. New York: Harper and Row, 143–61.

Ingold, T. 1993. The temporality of the landscape. *World Archaeology*, 25(2), 152–74.

Ingold, T. 2007a. *Lines: A Brief History*. London: Routledge.

Ingold, T. 2007b. Materials against materiality. *Archaeological Dialogues*, 14(1), 1–16.

Ingold, T. 2008a. *Bringing Things to Life: Creative Entanglements in a World of Materials*. [Online]. Available at: http://www.reallifemethods.ac.uk/events/vitalsigns/programme/documents/vital-signs-ingold-bringing-things-to-life.pdf [accessed: 09 September 2013].

Ingold, T. 2008b. Bindings against boundaries: Entanglements of life in an open world. *Environment and Planning*, 40, 1796–810.

Lewin, J. 2010. Medieval environmental impacts and feedbacks: the lowland floodplains of England and Wales. *Geoarchaeology*, 25(3), 267–311.

Mortimer. R. and McFadyen. L. 1999. *Investigation of the Archaeological Landscape at Broom, Bedfordshire, phase 4*. Cambridge: Cambridge Archaeological Unit (Report 320).

Rackham. O. 1994. *The Illustrated History of the Countryside*. London. Phoenix.

Ripper, S. and Cooper, L.P. (eds) 2009. *The Hemington Bridges: The Excavation of Three Medieval Bridges at Hemington Quarry, near Castle Donington, Leicester*. Leicester: University of Leicester Archaeology Monographs.

Witmore, C. and Webmoor, T. 2008. Things are us! A commentary on human/things relations under the banner of a social archaeology. *Norwegian Archaeological Review*, 41(1), 53–70.

Whatmore, S. 2002. *Hybrid Geographies: Natures, Cultures, Spaces*. London: Sage.

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Chapter 4

Suspended Animations: Mobilities in Rock Art Research

Ursula K. Frederick

Prologue

During an eighteen-month visit to Arnhem Land in 1922/23 overland adventurer Francis Birtles made a photograph of two Australian Aboriginal men with a dugout canoe and an Oldsmobile motorcar (Figure 4.1). Aside from the caption 'Going Alligator Hunting' written in pencil on the back, very little is known about the photo in the National Library of Australia collection (http://nla.gov.au/nla.pic-vn3302182). There is no indication of the identity of the individuals present within the image, nor do we know anything about the conditions under which the photograph was taken. The image would seem to suggest that the Aboriginal men were in the process of loading a canoe onto a car, when the younger man in the centre paused momentarily to face the camera.

Figure 4.1 Aboriginal man loading a canoe onto the car to go alligator [crocodile?] hunting, Northern Territory, Francis Birtles [Between 1899 and 1928]

Source: Reproduced courtesy of the National Library of Australia (nla.pic-vn3302182).

It is possible to regard Birtles' photograph within a broader genre of colonialist vision which imagines and represents 'untutored primitives looking on in astonishment at the wonders of the West' (DeLoria 2011: 250). But rather than picture this particular composition of man, car and canoe as a moment of first contact, a clash of cultures or a juxtaposition of progressive modernity and timeless indigenity, I view this photograph differently.

The primary focus of the photograph is the three inter-linked subjects at the centre of the frame. The Oldsmobile dominates the image by virtue of its size and position relative to the canoe and men. It faces us 'head on' so that we may observe the brand of the vehicle, both on the badge and written across the driver's shield. The canoe cuts diagonally across the horizontal axis of the image and connects the car to the Aboriginal man holding it up. The method of manufacturing dugout canoes was first introduced by seasonal fishermen from Maccassar (Indonesia) several centuries earlier and by the 1920s was well and truly integrated into the social, economic, and religious systems of Arnhem Land cultures (Tindale 1925, 1926, Rose 1942). We may assume that the canoe belongs to the Aboriginal man standing immediately behind it. The manner in which this man holds himself and the canoe, a strong yet comfortable stance, gives an impression of control and confidence. His appearance and proximity to the car, coupled with the absence of any white driver, also invites the viewer to imagine this man as the vehicle's owner. While it is difficult to know if this was the photographer's intention, for me, this is the effect.

In terms of the photograph itself there is no doubt that the convergence of old and new technologies set in a spartan landscape is used to striking effect. What makes the image more compelling is the opportunity that the image provides: to resist the idea of Aboriginal automobility as anomalous, or traditional culture as somehow static and unchanging.

There is much more that could be said about this image, despite the paucity of information that surrounds its production. In this sense my cursory attempt to read Birtles' photograph is not unlike scholarly efforts in approaching rock art. We do what we can with the little we have at our disposal. We examine the visual data we have before us, and whatever we know of its context, and use our knowledge and imagination to best effect. More than simply an analogy to the challenge of interpreting rock art, I employ Birtles' photograph here as a trigger. In the first instance, it raises the complex issue of representation and the tensions that generates. I am urged to recall that we can choose to read images and their histories differently, even if it goes against the grain of accepted discourse. Secondly, I wish to convey the very real importance that technologies of movement have played in the lives of hunter-gather groups of the past and in contemporary cultures (Indigenous and non-Indigenous) today. Finally, Birtles' photograph captured a moment in time and space, 'freezing' human action into light and shadow. It is stillness and movement rendered simultaneously, as suspended animation. I suggest that such a fusion, of motion and stasis as potentially coinciding attributes, may serve as a useful metaphor for comprehending both the constant and the dynamic aspects of rock art.

Introduction

Stepping into a rock shelter, my eyes flit across the surface of the walls, glancing left to right then up towards the ceiling and down towards the floor. My body is drawn inwards as I see a particular detail that I can't quite comprehend. Then my legs take me backwards to grasp a different perspective. I shift sideways, stepping over rocks while my hands stretch out for balance as I try to take in the entire rock art panel in a single field of view. Eventually I stop, sit still and contemplate the art around me.

What is obvious from the encounter I have outlined is that movement is fundamental to the very approach and experience of rock art. Yet rock art research, from the ways it is mapped, drawn, described, analysed and interpreted, has long been influenced by ideas of permanence, embeddedness and 'certainty in place' (Chippindale and Nash 2004: 7). In this chapter, I want to shift this emphasis by presenting a speculative and exploratory set of ideas based on my understanding of Australian rock art and the Aboriginal cultures that produced it. In brief, I wish to discuss how rock art moves. Rather than position this as a polemic, I suggest that the lens of mobility complements and expands existing models of rock art as fixed points in space. In this respect I am influenced by the agenda of the new mobilities paradigm, which acknowledges that movement and stasis are complementary forms.

Mobilities as a research framework

The study of mobility, as manifest through hunter-gatherer lifeways, technologies of movement, and cultural exchange has long been a focus of archaeological inquiry. Yet, in their efforts to map the course and detail of the past archaeologists have tended to adopt site-based or sedentarist models of thinking. Research designs, survey methodologies and techniques, analytical categories and the archaeological discourse itself all emphasise the identification of specific sites and the artefacts within them. This has resulted in an attention to place that has allowed us to better understand the specificities of particular living environments. But at times it can also represent a failure to recognise the linkages between places and the spaces that exist around and between them.

With the dawn of global exploration and colonisation the world has witnessed an increasingly mobile population facilitated by technological developments in ship, road, rail, air and space transport. Changing patterns in actual (and imagined) human movement have inevitably affected the ways the archaeological record is formed and demands that archaeologists reconceptualise their approaches to the material world. If we are to adequately grasp the archaeology of modernity, and archaeology as an outcome of modernity (Thomas 2004), we cannot afford to conduct research that is 'a-mobile' (Sheller and Urry 2006: 208). Going some way towards addressing this issue, the phenomenological, post-processualist

and landscape approaches of archaeology in recent decades (Bender 2001, 2002, Bradley 1997, Ingold 1993, Tilley 1994, 1996, 2004, David 2002) have offered a more dynamic framework through which to conceptualise the spatial and temporal relationships between people and place. Although many archaeologies now recognise that landscapes 'never stand still' (Bender 2002: 103) but instead are always in process, this attitude has yet to be fully embraced in archaeological analyses of rock art (Jones 2006: 211–2).

Another promising direction might be to consider archaeology through the lens of the new mobilities paradigm. A central tenet of this field of research is the emphasis on the complex relations between mobilities and immobilities, and the embodied experiences of and 'meanings attached to movement and stillness' (Sheller 2011: 1). Of particular relevance to rock art research is how this line of thinking seeks to account both for patterns of connection, movement, migration and dispersal but also the 'concomitant patterns of concentration' (Sheller and Urry 2006: 210) that give rise to movement being stalled or blocked: disconnection, exclusion and so on. Importantly for the practice of archaeology it also stresses how 'mobility is always located and materialized' (Sheller and Urry 2006: 210).

By accommodating stillness and fluidity concurrently, and anchorings within a context of movement, it would seem that a mobilities approach more closely resembles the way prehistoric peoples and hunter-gatherer societies might have lived within and related to their environment. As such it is well-suited to the study of rock art. Moreover, it also addresses the complexities of conducting archaeological research in the twenty-first century: when the tensions and slippages of being local and global, roots and routes, and belonging and being on the move are pressing realities (Bender 2001). Before turning my attention to mobilities in rock art I want to consider how a legacy of 'sedentary' thinking has developed and influenced rock art research.

Fixations in rock art research

One of the most notable characteristics of rock art, regardless of its age or location, is the fact that it occupies a stable location in space. Indeed, the non-portability of rock art is considered a defining attribute (Chippindale and Taçon 1998: 6, Chippindale and Nash 2004: 1–2). For many researchers it is the spatial constancy of rock art that gives it special merit and sets it apart from other kinds of archaeological data; as Chippindale and Nash declare: 'immovability is a central strength' (2004: 1). Unsurprisingly then, metaphors of spatial fixity dominate rock art discourse. Its status – as 'fixed in place' – is deployed commonly throughout the literature where it is often used synonymously with a suite of other evocative adjectives, including 'permanent', 'embedded', 'enduring' and 'ancient'.

Viewed as visible evidence of human behaviour rooted in and on the fabric of the land, rock art provides insights into the way space was communicated and places made and used. In other words rock art gives us some indication of

how peoples in the past perceived their worlds. Due to its fixed position rock art appears to be 'made and meant for the place where it is found and viewed' (Sanz et al. 2008: 21). Consequently, the production of rock art is perceived as redolent with intention and the associative meaning that intentionality invokes. It is this aspect of anchorage that also lends rock art its sensorial 'magic': as a metaphoric hinge between the 'artists' of the past and the 'viewers' of the present. The co-presence of rock art, across different temporal realities (Aldred and Sekedat 2010), also makes for a kind of cross-cultural engagement when we encounter rock art (Frederick 2012).

> Rock art is fixed in place. A human being once came to *this* very place and chose *this* very point on *this* very panel to make *this* very image. Walking or scrambling up to *that* place and standing in front of *that* panel to see *that* mark, observers today … repeat that physical journey and that physical presence. (Loendorf et al. 2005: 4, emphasis original).

In short there are many reasons why the spatial fixity of rock art may easily be taken for granted. And because rock art is *in* place, rock art researchers have tended to assume that it must be *about* place: 'rock art … is utterly dependent on, and hence in dialogue with, the place it is in, since it cannot be moved without altering its nature' (Heyd 1999: 454). One effect of a place-based paradigm is that rock art researchers end up relying upon site-specific models of recording, analysis and interpretation.

We may trace a site-focussed agenda and sedentarist line of thinking along different trajectories through the archaeological literature. On the one hand it is a legacy of the historical division of Palaeolithic art into two distinct categories: 'parietal' and 'mobiliary'. Commenting on the effect of this distinction, Lorblanchet (1977) noted that this rigid partitioning of art had an enormous influence on the approaches to style, categorisation and interpretation undertaken by Henri Breuil and his contemporaries and followers. Although in recent years researchers have come to question the use of this terminology, many rock art specialists continue to base their analyses on the distinction between art that is considered portable and that which remains 'stationary'. Abadia and Morales (2004: 322) argue that this division 'represents a dichotomy in the way artistic phenomena have been perceived' and, I would add, distorts the potential for illuminating continuities between different media and cultural processes.

In its tendency to assert the importance of the stationary, rock art research also divulges the broader influence of archaeology; a discipline which is profoundly shaped by theories of settlement, sedentary living and domestication. Because it is seen to relate to the emergence of complex symbolic relations to the material world (Renfrew 2007), the pre-eminence of the human settlement model has implications for the appreciation of prehistoric art. Yet, the pervasiveness of sedentism (Renfrew 2012) has ideological and political ramifications. For example, Carman (1999: 25) points to how the concepts of site and settlement are

inevitably tethered to 'concepts of domestication, civilization, the taming of the wild, and the planting of new people in an empty and unused land … it is a very colonialist discourse'.

While maintaining a critical awareness of our categories and their colonialist tenor is essential, it is also worth recognising the currency that 'sites' may carry in a contemporary post-colonial world. In nations scarred by histories of colonisation, the very immovability of rock art asserts the persistent presence of Indigenous people despite colonial strategies of dispossession. In Australia, for example, rock art may symbolise Aboriginal resilience and survival despite the tactics of the colonial project (Piotrowski and Ross 2011) and because it makes visible an ongoing Aboriginal presence, rock art also illuminates the affiliated links to land tenure and sovereignty that underpin its production. In this sense the endurance of rock art acts as a counter-argument to *terra nullius*, the lie by which Britain took possession of the Australian continent. Under such circumstances, the perceived permanence and stability of rock art plays an important role in consolidating the deep and enduring connections Aboriginal people have with their Country. Moreover, the currency of this endurance is more than symbolic. Under land rights legislation in Australia, Aboriginal individuals and communities may be granted ownership of the land if they can successfully demonstrate their continuous knowledge and unbroken attachment to it.

Nevertheless, one might well argue that to envisage rock art 'as distinct and spatially circumscribed points within a landscape' (Brück and Goodman 1999: 11) is to project onto the past distinctively Western models of property and land ownership. Such models are inconsistent with what we know from the anthropological and ethnoarchaeological literature and Aboriginal testimony today. Aboriginal Australian ontologies of landscape and affiliation to place demonstrate far greater dynamism and elasticity. To consider why a mobilities approach is particularly suited to examining rock art we must first consider the socio-cultural context in which it was, and is, produced.

The social contexts of Australian rock art

Australian rock art exists within the living entity that is *Country*, a terrain which is both ancestral and contemporary, that incorporates human beings, diverse animal and plant ecologies, geological features and weather systems, and which is governed by the Laws of Aboriginal cosmology, commonly referred to as the Dreaming. Rather than representing a single worldview that exists Australia-wide, the Dreaming is manifest 'as a range of geographically and culturally varied worldviews' (David 2006: 50) which share a number of consistent themes. The Dreaming is a 'dimension of reality … that was there in the beginning, underlies the present and is a determinant of the future' (Morphy 1998: 68). Through the Dreaming ancestral beings undertook epic journeys and through their actions created and shaped the world. Consequently, the landscape may be perceived as a

vast palimpsest of movement, representing ancestral energies that variously crawl, walk, run, hop, slither and fly. Morphy (1998: 84) observes that the record of these ancestral journeys are manifest 'not only in the form of the landscape, but also in the songs, dances, paintings, ceremonies and sacred objects they created on the way'. The generative power of this ancestral presence remains accessible and in some areas, the rights and responsibilities to Country are actualised through the performance of these activities, by renewing rock art and by 'walking in the footsteps of the ancestors' (Godwin and Weiner 2006 cited in Piotrowski and Ross 2011: 36) today.

Australian rock art research is strongly influenced by ethnoarchaeology and anthropological knowledge (David 2006, Layton 1992, Morwood 2002). Australian rock art researchers are generally aware of the relationships that exist, within a contemporary context, between rock art, Dreamings, and Country. As such, there is an implicit recognition that the themes of movement and mobility hold important implications regarding the conceptualisation and construction of socially constituted landscapes. For the most part rock art scholars have elected to represent the significance of Country as relationships of attachment (to land and sea). In short, the dominant paradigm for understanding rock art is to view it as a mode of 'place-marking' and 'place-making'.

Clearly, archaeological studies that recognise the location and position of rock art within the broader context of landscape (e.g. Bradley 1997) play an important role in research (Jones 2006, Ross 2001). However, it is also necessary to recognise the difficulties in reconciling a dynamic concept of landscape – as an ever unfolding sentient force in which all things are alive and entangled – with the notion of rock art as an isolated location with 'hard edges that can be identified' (Carman 1999: 23). In an Australian Aboriginal context, where the landscape itself is the trace of ancestral actions, this becomes all the more pertinent.

Evidence for mobilities

Despite the prominence given to fixity in space, there is also considerable evidence for mobility in rock art. If we turn our attention to the content of rock art we may find an enormous range of motifs that express an awareness and attention to movement. These include representations of lively anthropomorphic figures, narrative 'scenes' of dancing, ceremony, hunting and fishing as well as representations of animal life. Mobility clearly underpins the great number of track meanders (of possum, emu, kangaroo, etc.) that appear in rock art throughout Australia (Franklin 2007). In many instances these marks are tangible manifestations of the criss-crossing routes travelled by Dreaming ancestors which link to other places and marks in the landscape. Other examples of 'geometric' rock art may be map-like representations of the totemic geography (Flood 2004) which detail the itinerary of ancestral journeys. In some cases the rock art itself is visible evidence of where Dreaming beings 'sat down' or 'camped' (David 2006).

There are also paintings and petroglyphs of boats, horses, dugout canoes, camels, aeroplanes and cars (Figure 4.2); all technologies of movement that were introduced into Aboriginal cultures over time. These examples (Clarke and Frederick 2006, Layton 1992, O'Connor and Arrow 2008, Taçon 2012) are not simply representations of unfamiliar objects, they are images that reveal how new modes of mobility dramatically influenced the lives of Aboriginal people.

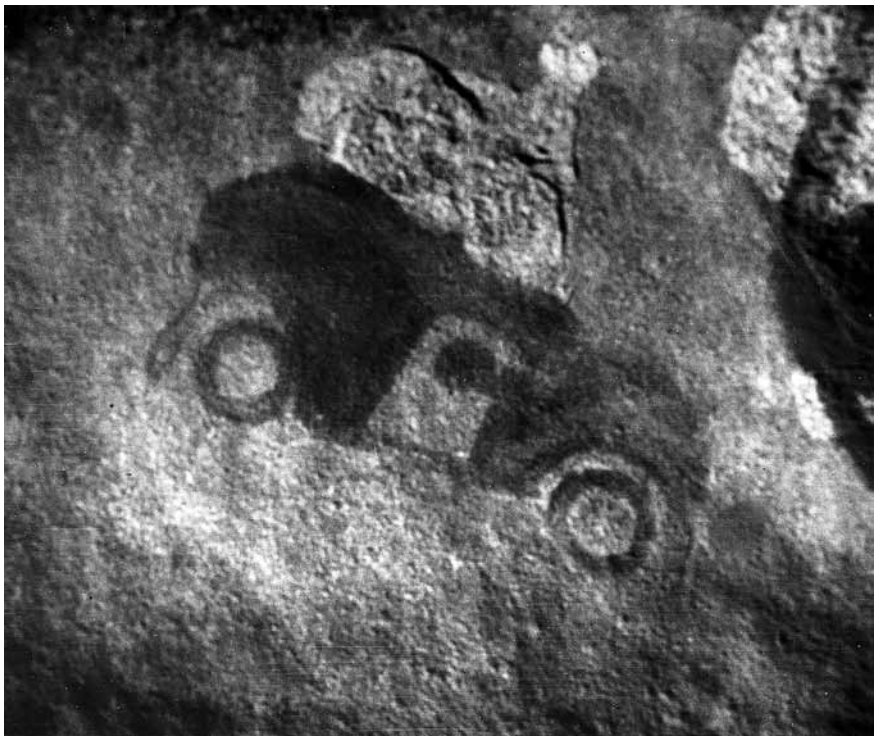

Figure 4.2 Aboriginal rock painting depicting a motor car, at the Granites, Northern Territory, 1928, Michael Terry
Source: Reproduced courtesy of the National Library of Australia (nla.pic-vn3069184).

An emphasis on movement may also be expressed in the manner by which subjects are represented. This mode of representation may in turn be viewed as an indicator of a distinctive style, as in the case of the Dynamic figures of Arnhem Land. 'The characteristic Dynamic figure is an animated human … Dynamic Figures often run, but other activities are depicted: standing; sitting; fighting in small groups (Taçon and Chippindale 1994); tumbling … ' (Chippindale et al. 2000: 63–5). Thus the conventions Aboriginal people used for depicting

gestures, actions and movements in rock art have been used to infer stylistic sequences, chronologies and regional patterns.

We may also consider the materials used in making rock art, because their procurement, exchange and preparation provides insight into the mobility of people and objects. Mineral pigments were an important item of exchange in many parts of Aboriginal Australia. Some prized ochres were traded across vast distances along established exchange routes (McCarthy 1939, Mulvaney 2002). Various pigment sources are also linked to the travels of ancestral beings, for example when the body of the ancestor spirit, or its blood, fat or excrement is transformed into a deposit of ochre (Elkin 1934, Morphy 1998, Mulvaney 1997). In turn, the production of rock art required and facilitated the maintenance of complex trading routes and intergroup partnerships.

Nor should we ignore the perceptual qualities and sensorial engagements with rock art that I alluded to in my introduction. Quite clearly our approaches to rock art are mediated through fieldwalking, driving, aerial surveys, and other ways of being mobile. Our direct encounters with rock art are also affected by the changing light and atmospheric conditions that come with the diurnal and seasonal rhythms of life. Other researchers have emphasised such movements in the viewing conditions of the past. Referring to rock art as a kind of cinema, Wachtel (1993: 37) notes how rock surfaces and spaces of a cave 'are never regular or predictable. Under a moving, flickering lamp, even the bare, irregular surfaces seem to come and go' so that Palaeolithic painters 'made images that appeared to move, images that cut or dissolved into each other, images that could fade into and out of existence'. He goes on to suggest that the still images of rock art recording fail to capture these cinematic qualities. In a related line of thinking, Azéma and Rivére (2012) argue that cave paintings were not only intended to represent movement but that sequential animation is evident in the rock art of Chauvet Cave and other Palaeolithic art/objects.

The idea that rock art may be abstracted from processes and landscapes of movement is clearly complex. How then might we overcome the inertia of 'site' to more explicitly engage with questions of movement? In the section that follows I provide a brief example of how Aboriginal responses to cross-cultural exchange, urged me to consider how mobility may be expressed in rock art.

Mobile people, moving rock art

At Watarrka (Kings Canyon) National Park in Central Australia the challenges and opportunities of thinking about movement presented itself in the form of a rock art assemblage comprising dry pigment (charcoal) drawings. A number of factors led me to propose that these drawings were made during a protracted period of contact between local Aboriginal people and non-Aboriginal 'outsiders' (see Frederick 2000, 2012 for further details).

Prior to the arrival of non-Aboriginal peoples, the landscape that is now Watarrka National Park might be conceived as an expansive entity of social and economic networks, linked to interconnecting places, *Tjukurrpa* (Dreaming) traditions and open mobility patterns. Following the arrival of non-Aboriginal explorers, first, and subsequently pastoralists and police into this area, the physical geography and its corresponding socio-cultural landscape was radically altered. With the movement of unfamiliar people, goods, and species into their lands, Aboriginal people experienced a profound transformation to their lives and their landscape as a consequence. Many Aboriginal people were killed or forcibly removed from their lands and others gathered closer to European settlements and ration depots (Mulvaney 2002). For many Aboriginal people ease of access to Country, and its associated resources and kin appear to have contracted.

Based on an analysis of the drawings in the broader context of the Watarrka rock art I examined, I proposed that the physical, economic and social spheres articulated in this emergent cross-cultural landscape was also expressed in the record of rock art produced during this time. This manifested itself both in the distribution and patterning of rock art as well as in the internal arrangement or 'design' of individual rock art graphics. I proposed that a process of dismantling and reassembling elements of the graphic tradition evident in the rock art might be seen to correspond with changing configurations in the social order of the landscape. In short, just as the socio-cultural landscape was being transformed rock art shifted also. Drawing upon ethnographic studies elsewhere for insight, I have argued that the trends evident in the Watarrka rock art assemblage might be explained as a means of reconfiguring landscape (Frederick 1997, 2000, 2012).

In the 1930s Charles Mountford, as a participant of anthropological expeditions to Central Australia, obtained a large number of crayon drawings made by Aboriginal people (the Ngadadjara, Luritja and Anangu) (Mountford 1937, 1939a, 1939b). This technique was a way of gathering information about traditional knowledge, land tenure, art motifs and 'their immediate, symbolic meanings … and lengthy mythological itineraries' (Jones 2011: 38). The drawings Mountford collected from the Ngadadjara, specifically relate to the journeys and Country surrounding Warburton during the *Tjukurrpa*. While the focus of the drawings was on Warburton, allusions to other locales, mythologically linked to that place, were incorporated into some of the graphics. These drawings not only demonstrate the multi-referential potential of Aboriginal graphic systems but also indicate the agency of the Aboriginal 'artists' in the graphic construction process. Namely, that through the manipulation of the graphic system, the artist was capable of referencing more than one place in any single drawing. Such conceptual linkages are evident in more recent anthropological literature and underscore the connections that exist between spatially disparate features as well as the intangible expressions and beliefs that underpin the material world. What it demonstrates, most importantly, is that Aboriginal peoples had a way of asserting their continued affiliation to Country despite their physical separation from it.

I have proposed that a similar mechanism of art production may have occurred at Watarrka during the period of contact. I have described this process as 'drawing from a distance' (Frederick 2012), by which I mean to imply an active embracing and articulating of landscape, an enfolding of several 'places' into a single locale. Drawing Country from a distance would, I believe, have served a two-fold purpose. Graphics associated with less accessible regions of the landscape could be integrated, from a distance, at and into places that remained accessible after contact. In this way, drawing became a means for recovering the distance between the artists and the totality of their Country, reaffirming the interconnectivity of its stories, places, ecologies and people. And in the process rock art became more elaborate, resonant with the echoes of these associations. A single graphic became a mnemonic for the wider landscape. This interpretation has obvious implications for our understanding of rock art, because within such a framework a singular rock art site may in fact reference many. In accordance with this model, the linkages between places become as integral to our reading of rock art as the 'sites' themselves.

In support of this interpretation I considered analogous situations, albeit in different Aboriginal communities. For example, elsewhere, Tonkinson records an example of how the imperative to maintain Country was fulfilled, overcoming dislocation and dispossession, by similarly creative means. He notes how some Aboriginal people travelled in dream-spirit form, back to Country to re-establish connections. This is an example, of the coexistence of stasis and movement in the practice of Aboriginal ontologies and everyday life. Similarly, Arndt (1962) relates how a Lightening Brothers site incorporating rock art was modified to accommodate changing access to land arising from the pastoral industry.

> … The Lightening Brothers originally 'camped' on Victoria River, where several neighbouring tribes were free to visit them. When the country and the people were divided by rival pastoral interests it was no longer practical for the Wardaman people to visit the [original] Lightning place. The Wardaman elders at Delamere Station decided that the Lightning Brothers could 'camp' at the Rain Place near the homestead so that they could be seen by the rising generation … Emu Jack 'dreamed' (visualised) the design and did the painting (Arndt 1962, cited in David et al. 1990: 79).

The 'movement' of rock art may also raise concerns, as demonstrated more recently when the rock art designs of the Wagiman people were reproduced in the National Aquarium of Baltimore. As Daryl Wesley explains, for the Wagiman people a sense of custodial responsibility for the rock art and sacred landscape of Umbrawarra Gorge did not end in the physical fabric of the place itself, but extended to include a reconstruction of Umbrawarra Gorge made in the United States. This case highlights the dynamic potential of the rock art landscape for contemporary Aboriginal people, and relates to how 'concepts of space and time

are very fluid within Indigenous traditional constructs'. (Guse cited in Hook et al. 2005: 39).

These examples, along with the case study from Watarrka, articulate how rock art sites may not be as fixed as we might at first imagine. Or as Bender succinctly states, 'places are not necessarily "in place", they may themselves be on the move' (Bender 2001: 85). It may well be the elasticity of the connections between people, place and landscape, encapsulated partially in rock art, that have ensured the possibility of ongoing relations, even in difficult circumstances. The dynamism of the Dreaming, which accounts for the shaping and reshaping of the land, points us to such a conclusion. The ancestors travelled *and* they sat down. Modalities of stasis and movement run parallel, crossover, and become entwined.

Conclusion

Mobility was integral to the access, making and maintenance of rock art images and landscapes. Whether it is seen to act as a portal for shamanic journeys into the spirit world (Lewis-Williams and Dowson 1990) or is a tangible link to the networked pathways of the Dreaming (e.g. Taçon et al. 2008) there are many ways in which mobility may be discerned in rock art. In some cases human movements reinforced the production of rock art, as is evidenced at aggregation sites (McDonald and Veth 2012). And because it facilitates the ongoing reproduction of relations between humans and the places they share, rock art might also be acknowledged as a locus of moving ideas in its own right.

Although rock art scholars are acutely aware of the movements that facilitated the meanings, motivations and contexts for producing rock art, few have yet to explicitly engage with mobility as a topic. I have suggested that simplistic associations between rock art, permanence and place can establish a sense of inertia that is out of step with the more dynamic conceptualisations of landscape evident in Indigenous ethnographies, histories and contemporary experience. When rock art is construed solely through statically rendered notions of site or place, at the expense of trajectories of movement and journeying, we are in danger of perpetuating the metaphors of colonial dominance. Given that settlement, occupation, agriculture and domesticity are powerful tropes of the colonial project, fixed notions of place might also be linked to the conquest of Indigenous peoples and lands. Without the parallel discourse of movement static renderings of place hide half the story. In short, spaces and connections themselves become reduced to spaces and connections between places, thereby losing their intrinsic relevance. A mobilities approach, by contrast, recognises that fixity and fluidity are co-existent and by considering its place in our research we will reanimate the study of rock art.

References

Abadia, O.M. and Morales M.R.G. 2004. Towards a genealogy of the concept of 'Paleolithic Mobiliary Art'. *Journal of Anthropological Research*, 60(3), 321–39.

Aldred, O. and Sekedat, B. 2010. *Part 1 of Moving on to Mobility: Archaeological Ambulations on the Mobile World*. [Online: Archaeolog]. Available at: http://traumwerk.stanford.edu/archaeolog/2010/12/moving_on_to_mobility_archaeol.html [accessed: 10 October 2012].

Arndt, W. 1962. The Nargorkun-Narlinji Cult. *Oceania*, 32(4), 298–320.

Azéma, M. and Rivére, F. 2012. Animation in Palaeolithic art: A pre-echo of cinema. *Antiquity*, 86: 316–24.

Bender, B. 2001. Landscapes on-the-move. *Journal of Social Archaeology*, 1(1), 75–89.

Bender, B. 2002. Time and Landscape. *Current Anthropology*, 43, 103–12.

Bradley, R. 1997. *Rock Art and the Prehistory of Atlantic Europe: Signing the Land*. London: Routledge.

Brück, J. and Goodman, M. 1999. Introduction: Themes for a critical archaeology of prehistoric settlement, in *Making Places in the Prehistoric World: Themes in Settlement Archaeology*, edited by J. Brück and M. Goodman. London: UCL Press, 1–19.

Carman, J. 1999. Settling on sites: Constraining concepts, in *Making Places in the Prehistoric World: Themes in Settlement Archaeology*, edited by J. Brück, and M. Goodman. London: UCL Press, 20–9.

Chippindale, C. and Nash, G. 2004. Pictures in place: Approaches to the figured landscapes of rock-art, in *The Figured Landscapes of Rock-Art: Looking at Pictures in Place*, edited by C. Chippindale and G. Nash. Cambridge: Cambridge University Press, 1–37.

Chippindale, C. and Taçon, P.S.C. (eds) 1998. *The Archaeology of Rock Art*. Cambridge: Cambridge University Press.

Chippindale, C., Smith, B. and Taçon, P.S.C. 2000. Visions of dynamic power: Archaic rock-paintings, altered states of consciousness and 'Clever Men' in Western Arnhem Land (NT), Australia. *Cambridge Archaeological Journal*, 10(1), 63–101.

Clarke, A. and Frederick, U. 2006. Closing the distance: Interpreting cross-cultural engagements through indigenous rock art, in *Archaeology of Oceania: Australia and the Pacific Islands*, edited by I. Lilley. Malden, Oxford and Carlton: Blackwell, 116–36.

David, B., McNiven, I., Flood, J. and Frost, R. 1990. Yiwarlarlay 1: Archaeological excavations at the Lightning Brothers Site, Delamere Station, Northern Territory. *Archaeology in Oceania*, 25(2), 79–84.

David, B. 2002. *Landscapes, Rock-art and the Dreaming: An Archaeology of Preunderstanding*. London: Leicester University Press.

David, B. 2006. Archaeology and the Dreaming: Toward an archaeology of ontology, in *Archaeology of Oceania: Australia and the Pacific Islands*, edited by I. Lilley. Malden, Oxford and Carlton: Blackwell, 48–68.

DeLoria P. 2011. The racial politics of the automobile, in *Major Problems in American Popular Culture*, edited by K. Franz and S. Smulyan. Boston: Wadsworth, Cengage Learning, 247–54.

Elkin, A.P. 1934. Cult-totemism and mythology in Northern South Australia. *Oceania*, 5(2), 171–92.

Flood, J. 2004. Linkage between rock art and landscape in Aboriginal Australia, in *The Figured Landscape of Rock Art: Looking at Pictures in Place*, edited by C. Chippendale and G. Nash. Cambridge: Cambridge University Press, 182–200.

Franklin, N. 2007. Aboriginal engravings in the southwest of Western Australia: Analysis of the Kybra Site. *Records of the Western Australian Museum* 24, 65–79.

Frederick, U. 1997. *Drawing in Differences: Changing Social Contexts of Rock Art Production in Watarrka (Kings Canyon) National Park, Central Australia*. Unpublished MA thesis, Australian National University.

Frederick, U. 2000. Keeping the land alive: Changing social contexts of landscape and rock art production, in *The Archaeology of Difference. Negotiating Cross-cultural Engagements in Oceania*, edited by R. Torrence and A. Clarke. London: Routledge, 308–38.

Frederick, U. 2012. When worlds collide quietly: Rock art and the mediation of distance, in *A Companion to Rock Art*, edited by J. McDonald and P. Veth. Chichester: Blackwell, 401–19.

Guse, D. 2005. *A Tale of Two Gorges: Wagiman Rock Art and Sacred Places in the Northern Territory, Australia and Maryland, USA*. Unpublished conference presentation. Australian Archaeological Association and Australasian Institute for Maritime Archaeology Conference.

Heyd, T. 1999. Rock art aesthetics: Traces on rock, mark of spirit, window on land. *Journal of Aesthetics and Art Criticism*, 57, 451–8.

Hook, F., Paterson, A. and Souter, C. (eds) 2005. *The Archaeology of Trade and Exchange: Program and Abstracts of the 2005 Australian Archaeological Association and Australasian Institute for Maritime Archaeology Conference*. Archaeology, School of Social and Cultural Studies, University of Western Australia, Crawley, Western Australia & Western Australian Maritime Museum, Fremantle, Western Australia.

Ingold, T. 1993. The temporality of the landscape. *World Archaeology*, 25(2), 152–74.

Jones, A. 2006. Animated images: Images, agency and landscape in Kilmartin, Argyll, Scotland. *Journal of Material Culture*, 11(1/2), 211–25.

Jones, P. 2011. Inside Mountford's tent: Paint, politics and paperwork, in *Exploring the Legacy of the 1948 Arnhem Land Expedition*, edited by M. Thomas and M. Neale. Canberra: ANU E Press, 33–54.

Lewis-Williams, D. and Dowson, T. 1990. Through the veil: San rock paintings and the rock face. *South African Archaeological Bulletin*, 45, 5–16.

Layton, R. 1992. *Australian Rock Art: A New Synthesis*. Cambridge: Cambridge University Press.

Loendorf, L., Chippindale, C. and Whitley, D.S. 2005. The discovery of North American rock art and its meanings, in *Discovering North American Rock Art*, edited by L. Loendorf, C. Chippindale, and D.S. Whitley. Tucson: University of Arizona Press, 3–11.

Lorblanchet, M. 1977. From naturalism to abstraction in European prehistoric rock art, in *Form in Indigenous Art: Schematisation in the Art of Aboriginal Australia and Prehistoric Europe*, edited by P. Ucko. Canberra: Australian Institute of Aboriginal Studies, 44–56.

McCarthy, F.D. 1939. Trade in Aboriginal Australia, and trade relationships with Torres Strait, New Guinea and Malaya. *Oceania*, 10(1), 80–104.

McDonald, J. and Veth, P. 2012. *A Companion to Rock Art*. Chichester: Blackwell.

Morphy, H. 1998. *Aboriginal Art*. London: Phaidon.

Morwood, M.J. 2002. *Visions from the Past: The Archaeology of Australian Aboriginal Art*. Washington DC: Smithsonian Institution Press.

Mountford, C.P. 1937. Aboriginal crayon drawings: relating to totemic places belonging to the northern Aranda tribe of Central Australia. *Transactions of the Royal Society of South Australia*, 61, 81–95.

Mountford, C.P. 1939a. Aboriginal crayon drawings, IV: Relating to every-day incidents of the Ngada tribe of the Warburton Ranges of Western Australia. *Transactions of the Royal Society of South Australia*, 63, 1–13.

Mountford, C.P. 1939b. Aboriginal crayon drawings, Warburton Ranges, Western Australia. *Oceania*, 10, 72–9.

Mulvaney, J. 2002. … these Aboriginal lines of travel. *Historic Environment*, 16(2), 4–7.

Mulvaney, K. 1997. *More than a chip off the old block*. Unpublished MA dissertation, Northern Territory University, Darwin.

O'Connor, S. and Arrow, S. 2008. Boat images in the rock art of northern Australia with particular reference to the Kimberley, Western Australia, in *Islands of Inquiry (Terra Australis 29) Colonisation, Seafaring and the Archaeology of Maritime Landscapes*, edited by G. Clark, F. Leach and S. O'Connor. Canberra: ANU E press, 397–409.

Piotrowski, S. and Ross, A. 2011. Aboriginal epistemologies and interpretations of art and place on the Blue Tier, Northeast Tasmania. *Australian Archaeology*, 73, 33–40.

Renfrew, C. 2007. *Prehistory: The Making of the Human Mind*. London: Weidenfeld & Nicolson.

Renfrew, C. 2012. Towards a cognitive archaeology: Material engagement and the early development of society, in *Archaeological Theory Today*, edited by I. Hodder. Second edition. Cambridge and Malden: Polity Press, 124–45.

Rose, F. 1942. Paintings of the Groote Eylandt Aborigines. *Oceania*, 13(2), 170–6.

Ross, M. 2001. Emerging trends in rock-art research: Hunter-gatherer culture, land and landscape. *Antiquity*, 75, 543–8.

Sanz, I.D., Fiore, D. and May, S.K. 2008. Archaeologies of art: Time, place and identity in Rock Art, Portable Art, and Body Art, in *Archaeologies of Art: Time, Place and Identity*, edited by I.D. Sanz, D. Fiore, and S.K. May. Walnut Creek: Left Coast Press, 15–28.

Sheller M. 2011. *Mobility*. [Online: Sociopedia.isa]. Available at: http://www.sagepub.net/isa/resources/pdf/Mobility.pdf [accessed: 10 July 2013]

Sheller, M. and Urry, J. 2006. The new mobilities paradigm. *Environment and Planning A*, 38(2), 207–26.

Taçon, P.S.C. and Chippindale, C. 1994. Australia's ancient warriors: Changing depictions of fighting in the rock art of Arnhem Land, N.T. *Cambridge Archaeological Journal*, 4(2), 211–48.

Taçon, P.S.C., Kelleher, M., King, G. and Brennan, W. 2008. Eagle's Reach: A focal point for past and present social identity within the Northern Blue Mountains World Heritage Area, Australia, in *Archaeologies of Art: Time, Place and Identity*, edited by I.D. Sanz, D. Fiore, and S.K. May. Walnut Creek: Left Coast Press, 195–214.

Taçon, P.S.C., Ross, J., Paterson, A. and May, S. 2012. Picturing change and changing pictures: Contact period rock art of Australia, in *A Companion to Rock Art*, edited by J. McDonald and P. Veth. Chichester: Blackwell, 420–36.

Thomas, J. 2004. *Archaeology and Modernity*. London: Routledge.

Tilley, C. 1994. *A Phenomenology of Landscape: Places, Paths and Monuments*. Oxford: Berg.

Tilley, C. 1996. The powers of rocks: Topography and monument construction on Bodmin Moor. *World Archaeology*, 28, 161–76.

Tilley, C. 2004. *The Materiality of Stone: Explorations in Landscape Phenomenology*. Oxford: Berg.

Tindale, N.R. 1925. Natives of Groote Eylandt and of the west coast of the Gulf of Carpentaria: Part 1. *Records of the South Australian Museum*, 3, 62–102.

Tindale, N.R. 1926. Natives of Groote Eylandt and the west coast of the Gulf of Carpentaria: Part 2. *Records of the South Australian Museum*, 3, 103–35.

Wachtel, E. 1993. The first picture show: Cinematic aspects of cave art. *Leonardo*, 26(2), 135–40.

Chapter 5

GIS Approaches to Past Mobility and Accessibility: An Example From the Bronze Age Khanuy Valley, Mongolia

Oula Seitsonen, Jean-Luc Houle and Lee G. Broderick

Introduction

Geographic Information Systems (GIS) have been frequently used in the past decades to describe and reconstruct past mobility (see e.g. Gaffney and Stančič 1991, Howey 2011, Kvamme 1999, Llobera 2000). The most common methods for examining movement patterns have been the defining of site catchment areas, either based on the Euclidean distance or relative cost of movement across the terrain, and modelling least-cost pathways and corridors (see e.g. Carballo and Pluckhahn 2007, Howey 2007, 2011, van Leusen 2002, Lock and Harris 1996, Zakšek et al. 2008). Recently several authors, for instance Fábrega-Álvarez (2006), Whitley and Burns (2008), Murrieta-Flores (2010), Llobera et al. (2011), and Mlekuz (forthcoming) have paid attention to the wider possibilities that application of GIS mobility and accessibility analyses can offer for archaeological interpretation, moving beyond the construction of pathways or corridors and extending to broader analyses of landscape utilization and perception, also in a non-utilitarian sense (see Whallon 2006).

In this chapter we describe on-going GIS analyses of past mobility and accessibility patterns in the Late Bronze Age Khanuy Valley, Mongolia *c*.1300–700 BC (Figure 5.1; e.g. Allard and Erdenebaatar 2005, Allard et al. 2006). GIS studies build on field research and analyses carried out in the area over the past decade (e.g. Allard et al. 2006, Houle 2009a-b, 2010, Houle and Broderick 2011). Khanuy Valley is presently one of the few areas in Mongolia where Bronze Age research has systematically focused on locating and studying occupation areas (i.e. settlement sites; see Houle and Broderick 2011, for a discussion of the terminology used here). Earlier research has concentrated largely on monumental studies, especially on the khirigsuur monuments, the Mongolian equivalent of the kurgans encountered across the Bronze Age and Iron Age Eurasian steppe (e.g. Allard and Erdenebaatar 2005, Wright 2007).

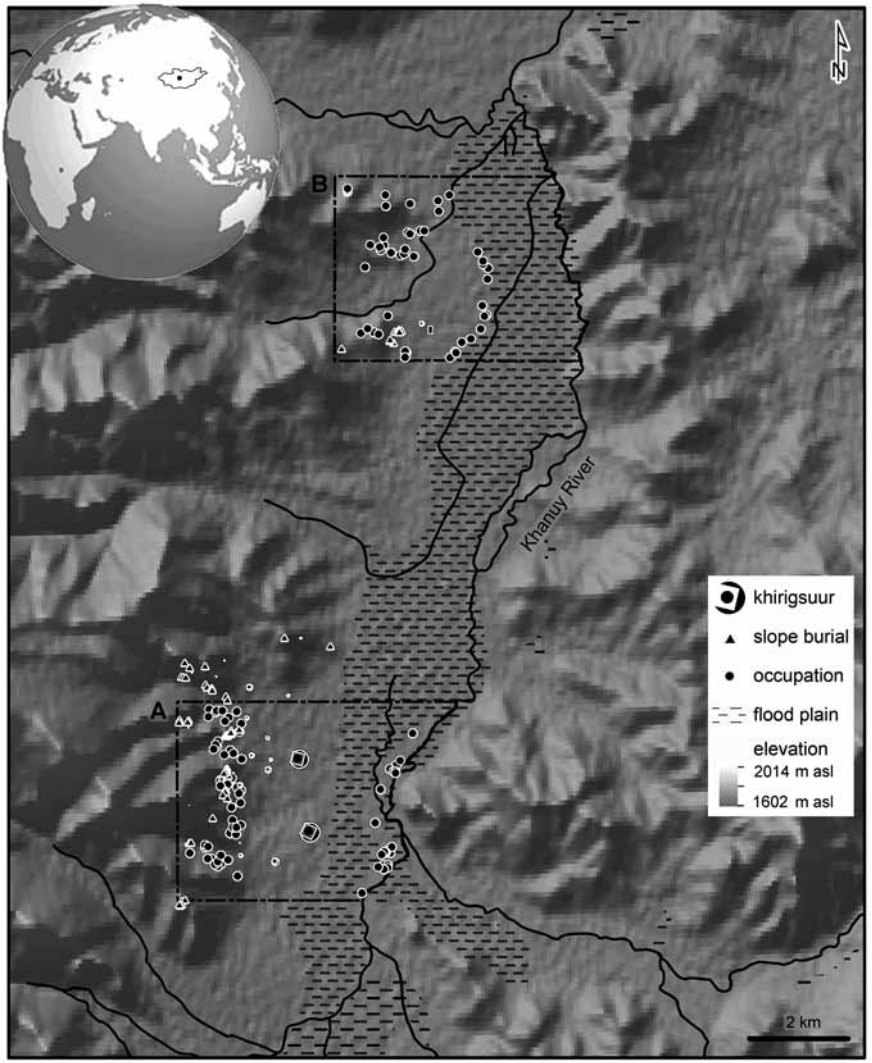

Figure 5.1 Location of the study area, and the archaeological features recorded during the systematic survey in the areas A and B;
Source: Illustration: O. Seitsonen 2012; ASTER GDEM is a product of METI and NASA, and provides base data for figures in this chapter.

Here we provide an overview of the theoretical and methodological background used for GIS studies, mainly time-geography as defined in the 1960s–70s by Torsten Hägerstrand (1970), and briefly describe observations on the Late Bronze Age movement and accessibility patterns in the Khanuy Valley. GIS analyses in this stage of research were mainly used to test working hypotheses from a new

perspective, connected, for example, to the local and supra-local mobility patterns and possible origins of social complexity. GIS oriented studies in general have been scarce in Mongolian archaeology (but see Wallace and Frochlich 2005, Wright 2009). The data from the Khanuy Valley enables inquiries of the relations between domestic and monumental sites, e.g. considerations about how the various kinds of sites might have provided order for the natural landscape and its utilization, and how this might have affected the mobility, accessibility, and settlement patterns. These will be presented briefly below, and discussed in more detail elsewhere alongside various other lines of inquiry.

Time-geography and archaeology

In the 1960s Torsten Hägerstrand of the University of Lund defined the basis for time-geography: a theoretically informed conceptual approach for analysing and describing human behaviour and movement in space and time (Hägerstrand 1970). This approach was further elaborated in the 1970s–80s (e.g. Hägerstrand 1973, 1975, 1989, Miller 1991, 2005, Pred 1977, 1990). Time-geography builds on an empirical set of temporal constraints, needs, and possibilities for human mobility: e.g. all human lives are constructed of activities carried out in space and time and every act is preceded and guided by the earlier acts (Hägerstrand 1970, Kraak 2003, Miller 2005).

Time-geography is well suited for archaeological analyses, since all useful archaeological data have both a spatial and temporal component. It was originally developed by Hägerstrand (1970) around the question ‘what about people in regional science’, and aims to bring human behaviour into the focus of research by assessing individuals’ needs and constraints in the course of their activities, which form a complex web of social and spatial networks of varying time-spans (e.g. Forer et al. 2007). In past contexts this ‘choreography of existence’ (Pred 1977) is ‘collapsed’ into sets of archaeologically discernible features, preservation of which defines the temporal scope of analysis: most often this means examining the potential mobility patterns, since exact temporalities are lacking (e.g. Mlekuz forthcoming).

One of the essential concepts of time-geography was a space-time aquarium (STA), from a visualization perspective the most prominent feature of the time-geographical approach (Figure 5.2): the two-dimensional base of the aquarium presents geographical space on the x- and y-axis, while time is presented on the z-axis (e.g. Hägerstrand 1970, Kwan and Lee 2004). Initially this was also one of the limiting factors on the use of time-geographical visualization, since STA had to be hand drawn each time a perspective was changed or a new analysis carried out (e.g. Kraak and Koussoulakou 2004, Orford et al. 1998: 24). However, lately STA has been assimilated into the GIS world as a Space-Time-Cube (STC), a fully three-dimensional analysis and visualizing environment for movement studies (e.g. Kraak 2003). STC has so far been little experimented with in archaeological

contexts (see Huisman et al. 2009, Kraak and Huisman 2009), but it has potential for becoming a powerful analytical and visualisation tool once its applications and incorporations into archaeological analyses are further developed. In particular, the 3D analysis and visualization possibilities of STC have a lot of potential for archaeological studies of mobility and accessibility (c.f. Forer et al. 2007, for a non-archaeological example).

In fact many of the regularly applied archaeological GIS analyses find their theoretical bases in time-geography (see Huisman et al. 2009, Llobera 2000, Mlekuz forthcoming). For instance, the often used isochronic catchment areas modelled around sites (e.g. Birkett 1985, Gaffney and Stančič 1991: 37, Higgs 1975: 223–4, Roper 1979) are actually Potential Path Areas (PPA; also known as action spaces), i.e. 2D representations of Potential Path Spaces of Space-Time Prisms (STP), which cover the space that can be reached within an allocated time-budget from a starting point (Figure 5.2; see Hägerstrand 1970, Mlekuz forthcoming). When applied to modelling travel between two points this comes out as a least-cost corridor (e.g. Howey 2011), a PPA of an STP with differing start and end points. Also the MADO approach (Spanish acronym for 'Optimal accumulation model of movement from a given origin') developed by Fábrega-Álvarez (2006) builds on a time-geographical basis in its description of potential path coverage (see also Fábrega-Álvarez and Parcero-Oubiña 2007, Llobera et al. 2011).

Potential Path Areas, or site catchments, have been most commonly used for estimating potential resources accessible during movement within the PPA, such as availability of agricultural land or lithic raw materials. This is founded, implicitly or explicitly, in optimal foraging theory and the law of diminishing returns (e.g. Gaffney and Stančič 1991: 60, Roper 1979, Seitsonen 2009, Vita-Finzi and Higgs 1970) and sizes of the PPAs have often been estimated on the basis of anthropological studies (e.g. Lee 1969, for hunter-gatherers; Chisholm 1968, for agriculturalists). However, several studies have criticized the lack of attention that the early studies (especially) paid to socially motivated perspectives, such as culturally distinct landscape perception(s), e.g., restricted taboo areas, habitually used pathways, and various kinds of social networks; all of which can results in PPAs that deviate from the optimizing land-use strategies (e.g. Bender 1993, Gaffney et al. 1996, Hodder and Orton 1976: 233–6, Wheatley 2004, Wheatley and Gillings 2002: 145, Witcher 1999). In recent years there have also been attempts to incorporate more interpretative, idiosyncratic, cultural perspectives into GIS analyses (e.g. Harmsworth 1998, Lock and Harris 2006, Ridges 2006, Wheatley 1993, Wheatley and Gillings 2000).

Time-geographical methodology might offer some new ways to examine socially endemic landscape perceptions in analyses. Mlekuz (forthcoming) has recently suggested cumulative PPAs (c.f. Wheatley 1995, cumulative viewsheds) as one potential approach to examine the conditions for interaction and avoidance. Cumulative PPAs highlight areas reachable from multiple starting points within the same time-budget with higher potential for interaction, as well as barrier areas which potentially prevent activities from happening (also Pred 1977: 210).

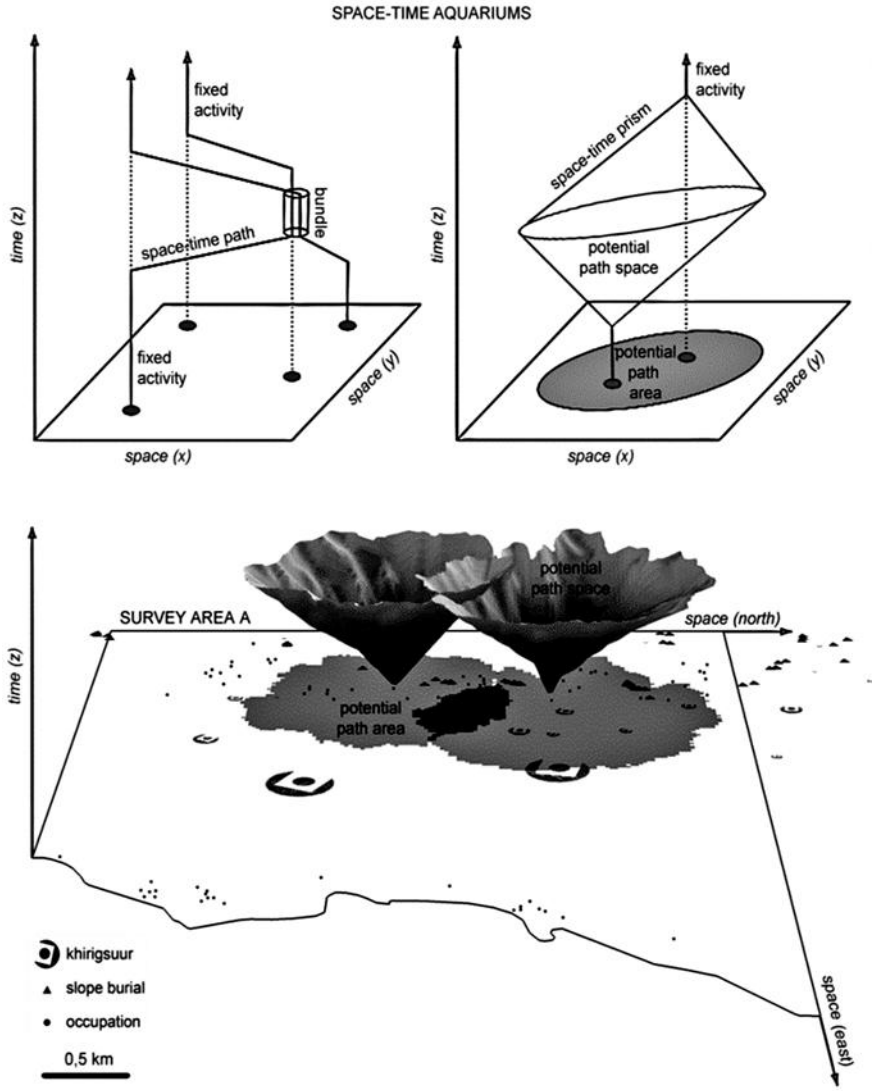

Figure 5.2 Top: Basic concepts of Hägerstrand's time-geography (Illustration: O. Seitsonen 2011, based on Hägerstrand 1970, Miller 2005, Mlekuz forthcoming); Bottom: 2,5 D presentation of intersecting 30 minute Potential Path Spaces (only out-travel presented) and their Potential Path Areas from two Bronze Age occupation areas in the survey area A (illustration by O. Seitsonen 2012)

Mlekuz (forthcoming) aptly describes 'landscape as a vehicle for interaction and the ways daily practices structure the long-term material record … '. Van Leusen (2002) has also proposed visibility and cost surface analyses as prospective tools for more cognitive landscape analyses (also e.g. Wheatley and Gillings 2000). Time-geography's power lies in the simple and empirically strong approach which builds on the pragmatic physical constraints and limitations on the human movement set by time, terrain and topography, while also exhibiting well-founded potential to approach the more interpretative and culturally idiosyncratic measures of past behaviour (e.g. Huisman et al. 2009, Kraak 2003, Murrieta-Flores 2010, Wheatley and Gillings 2000).

Factors affecting human movement potential can be analytically divided into 'independent variables', i.e. external influences such as topography, time, and terrain types, and into 'social variables', such as culturally idiosyncratic landscape cognizance, beliefs, social territories, and visibility; in reality these two considerations always work in interaction with each other and form the basis for a decision making process while travelling or planning a journey (Murrieta-Flores 2010). In our analyses an attempt is made to take both of these lines of evidence into account, independent variables through GIS methods connected to classifying topography and terrain types for mobility analyses (e.g. Llobera 2000, Murrieta-Flores 2010) and social variables from a time-geographical viewpoint (e.g. van Leusen 2002, Mlekuz forthcoming, Murrieta-Flores 2010). Palaeoenvironments also need to be taken into account when analysing past movement and patterns (e.g. Roper 1979); however, in the Khanuy Valley the Bronze Age environment seems to have been broadly similar to that of today (see below).

Bronze Age Khanuy Valley: Settlement in a monumental landscape

The Khanuy Valley is situated in an isolated part of the Arkhangai *aimag* (province) in north-central Mongolia (Figure 5.1). It lies directly north of the Khangai Mountains, the second largest mountain range in Mongolia. The valley itself varies in width from three to five kilometres and is surrounded on both eastern and western sides by mountains rising 200–400 m above the valley floor (Figure 5.3). The valley bottom and most of the foothills are covered by treeless steppe, providing ample grazing for animals, with some forested patches along the Khanuy River and mixed forests covering the higher slopes of mountains. The Khanuy River itself is a relatively shallow and meandering stream less than 15 m wide at its widest point during the summer months (e.g. Houle 2010). This narrow stream is fordable in most places, at least on horseback. Based on various palaeoenvironmental inquiries, the environment seems to have been broadly similar in the Late Bronze Age, with a more humid period of grassland expansion *c*.3400–1500 years ago (Houle and Broderick 2011).

The Khanuy Valley has been the stage for intensive archaeological studies over the last decade (e.g. Allard and Erdenebaatar 2005, Allard et al. 2006,

Houle 2009a-b, 2010). In the course of these studies systematic surveys were carried out to locate Bronze Age occupation areas, previously unknown in the area. Mongolian Bronze Age research has earlier centred on monumental sites, such as khirigsuurs and deer stones (Figure 5.3; e.g. Bayarsaikhan 2005, Erdenebaatar 2002, 2004, Fitzhugh 2005, Wright 2006: 54, 2007); two of Mongolia's largest known khirigsuur monuments and the largest deer stone complex of Jargalantyn Am are located in our study area (see Allard and Erdenebaatar 2005, Allard et al. 2006, Bayarsaikhan 2011, Fitzhugh 2009). On the basis of recent research, various kinds of Bronze Age monuments, such as khirigsuurs, slope burials, slab burials, and deer stones, seem to be all part of the same broadly contemporaneous monumental package (Figures 5.3–5.5; e.g. Bayarsaikhan 2011, Houle 2009a-b, 2010). In future analysis their inter-relations and internal chronologies should be further studied (e.g. Honeychurch 2004, Tsybiktarov 1998); in fact, many of them seem to have maintained their importance also in the later times, as is suggested by the adding of Iron Age and even later features, such as Turkic period balbals (stone lines), into the monuments of Bronze Age origin.

Monumental sites are without doubt vital when assessing the mobility patterns: as visually outstanding loci they have provided order to the natural landscape and for movement within it (e.g. Bradley 1991, Llobera 2001, Llobera et al. 2011, Lock and Harris 1996). However, without proper settlement data context they represent solely the landscape of the dead (Houle 2009a). Of course, locations of settlement sites are always governed by a basic set of topographical, ecological and economic factors, such as level land, good pasture, and availability of water (e.g. Kvamme 1985), but they are also governed by more interpretative social aspects, as presented for instance by the culturally constructed and interpreted monumental landscape (e.g. Hamilton et al. 2006, Jerpåsen 2012, Tilley 1994, 2004).

Occupation areas were surveyed within two 20 km^2 areas (Figure 5.1: A and B) using a stratified sampling of the landscape in four ecological contexts: by the foothills, on the plain below, on the floodplain, and by the Khanuy River (Houle 2009a-b, 2010). This involved systematic digging of nearly 7700 shovel probes every 30 by 20 m in the foothills and by the river and systematic unalignedsampling of the other environmental contexts (Houle 2010, Houle and Broderick 2011). Numerous shovel probes unearthed Bronze Age and Iron Age settlement material, namely ceramics, faunal remains and lithics. Positive shovel probes provided the primary unit for landscape level analyses in an off-site manner (e.g. Foley 1981), and occupation areas were defined as the higher density concentrations of find materials. Several of these locations were excavated in the subsequent years, to obtain interpretations about the functional site types, seasonality, and mobility patterns.

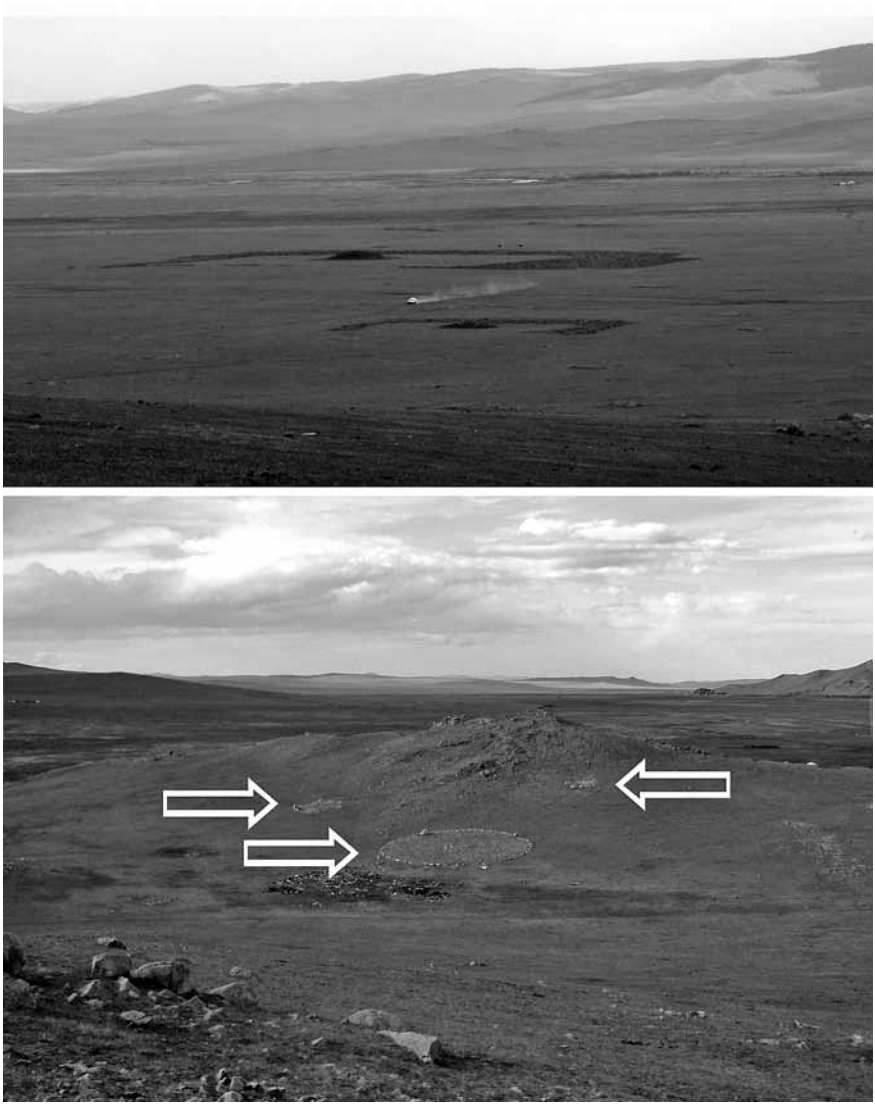

Figure 5.3 Top View from a modern pastoralist winter camp site, in the foreground a small khirigsuur and on the plain a large khirigsuur (KYR-1), notice the light coloured jeep as a scale; Bottom: Three slope burials (white arrows) in the survey area B

Source: Photographs: O. Seitsonen 2010.

Based on the excavated evidence, e.g. on the zooarchaeological material and the proportions of faunal remains to potsherds, the Bronze Age settlement pattern in the area seems to have been one of highly tethered mobility: with winter campsites situated by the foothills in well protected valley draws and summer camps along the river (Figure 5.4; Houle 2010). This resembles the area's modern pastoralist 'Khangai' settlement pattern with winter and summer camps situated only some kilometres apart thanks to the constant good pasturelands which enable this limited mobility (see Bazargür 2005, Erdenebaatar 2000, Vainhstein 1980). Actually, most of the Bronze Age occupation areas are located at or next to modern pastoralists' seasonal camps (Houle 2009a, 2010).

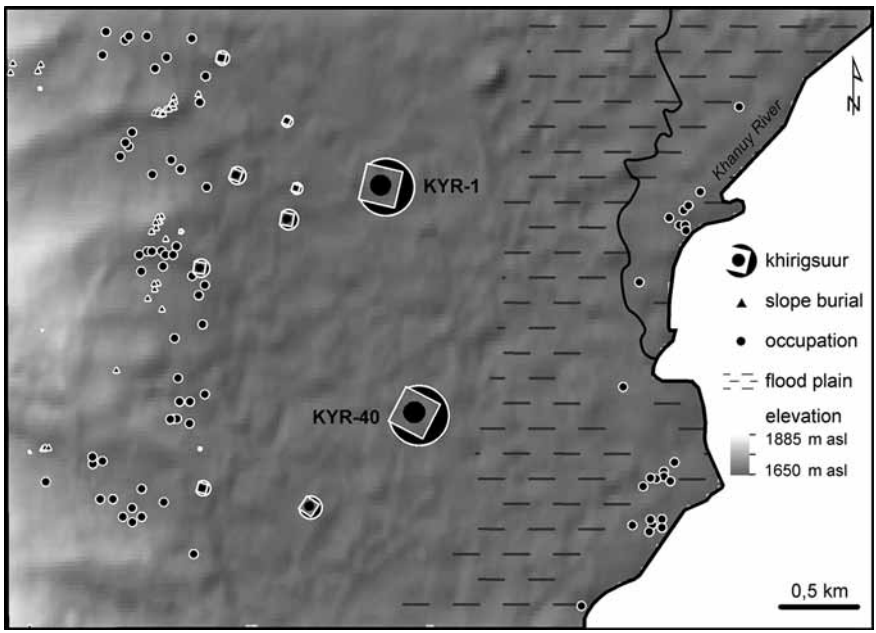

Figure 5.4 Archaeological features observed in the survey area A
Source: Illustration by O. Seitsonen 2011.

Khirigsuurs are a Mongolian version of the kurgan burial mounds found widely over the Eurasian steppe zone. Typically khirigsuurs exhibit a common set of complex features, such as a rectilinear or circular fence surrounding the central mound, satellite mounds situated on the east and south sides, also known as horse head mounds since excavations typically reveal a horse head burial, stone circles situated especially on the west side, and occasionally a stone-paved pathway usually on the northern side (Figures 5.3, 5.5; Allard and Erdenebaatar 2005, Houle 2009a, Wright 2007). Typical characteristics include their roughly west-

east orientation, probably towards some cardinal points in the landscape or in the sky; the alignment of horse heads revealed from satellite mounds follows this closely (Allard and Erdenebaatar 2005, Wright 2007). Several studies suggest that khirigsuurs are burial sites of persons of importance and higher ranking, possibly even of a hereditary spiritual or political leadership status, based for example on the infant burials found in some of them (Erdenebaatar 2002, Houle 2009a, Tsybiktarov 1998). However, they apparently also acted as centres and stages for communal rituals (Houle 2010, Wright 2006: 215, 2007, see Koryakova 1996: 256, for similar interpretations in the Southern Urals). It has been suggested that in the Late Bonze Age the collective rituals might have been an important, even principal, means of gaining and sustaining a high social status, either spiritual, political, or both (Houle 2010: 189; see Clark and Blake 1994, Hayden 1995).

Khirigsuurs are usually found in clusters, with virtually empty 'buffer' zones between them: within the Khanuy Valley seven such clusters have been recorded (Houle 2009a); the high density of monuments correlates with the contemporary settlement density (see Honeychurch 2004, for a similar pattern in Northern Mongolia). Thus the monuments seem to have been marking central areas of human activity, and might have acted as landscape markers for both the locals and outsiders (Houle 2009a).

In many areas of Mongolia all Bronze Age monuments are simply called khirigsuurs. However, in our study area Houle (2009, 2010) managed to separate the monuments into two apparently (socially) functional classes, that is khirigsuurs and slope burials; the latter have also been called Class III mounds in other areas (e.g. Wallace and Frohlich 2005). Khirigsuurs are mostly situated on the plains below the foothill zone and have the complex characteristics described above, whereas slope burials are found on the foothills above or adjacent to contemporary occupation areas, and often lack khirigsuur features (Figures 5.3, 5.4). Slope burials seem to have been burials representing a more intimate connection to the domestic setting, e.g. family or kinship ties, than the wider communal ritual setting presented by the khirigsuurs (Houle 2009a, 2010: 13–5).

Since the study area includes the two largest known khirigsuurs in all Mongolia, KYR-1 and KYR-40, and both of these are situated in relative solitude on the edge of the flood plain of the Khanuy River (Figures 5.3, 5.4), they have been dealt with separately from the smaller khirigsuurs in the spatial analyses. The largest khirigsuurs are massive monuments both in their size and in the number of attached satellite features. The KYR-1 has a central mound of *c*.26 m in diameter and five meters tall and has altogether *c*.1700 satellite mounds; whereas KYR-40 has over 2300 satellite mounds and *c*.1000 stone circles (Figure 5.5). Radiocarbon dates from excavations of horse head burials in the inner and outer fringes of KYR-1 satellite mound zone show the studied structures were practically contemporary (2970–2780 BP and 2980–2770 BP, 2-sigma accuracy; Fitzhugh 2009), suggesting these large monuments were built relatively swiftly and according to a plan instead of being outcomes of recurring building phases through time (Houle 2010: 31).

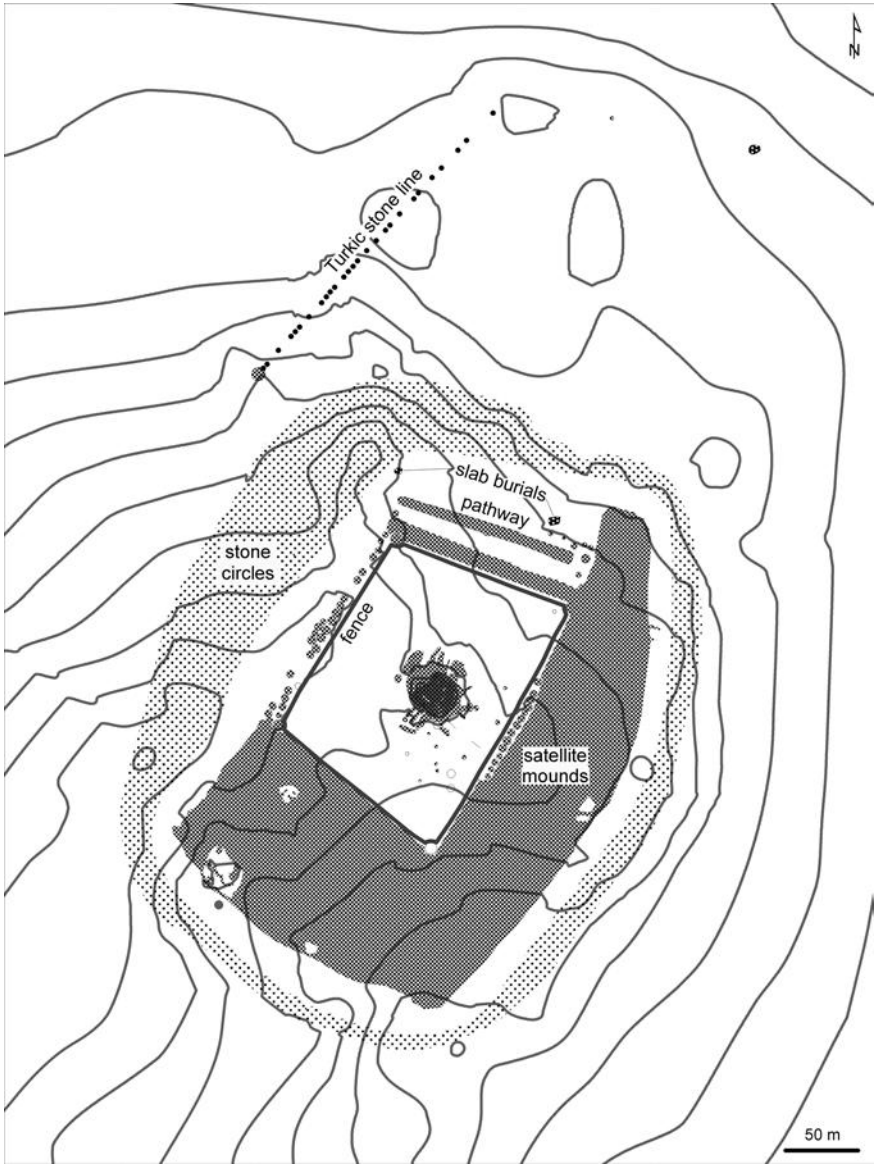

Figure 5.5 General map of the largest khirigsuur KYR-40 mapped in 2011; contours at 0,5 m intervals

Source: Illustration by O. Seitsonen 2011.

KYR-1 and KYR-40 seem to represent communal work efforts that were most likely beyond the Bronze Age inhabitants of local social unit(s), even if all contemporaneous occupation areas would have been simultaneously inhabited (Houle 2009a, 2010). We suggest that they could be representations of more complex social networks extending beyond the local level, integrating the supra-local community, and possibly leading to some level of social complexity (Houle 2010: 189). This hypothesis has been examined for instance with the GIS accessibility analyses (see below).

GIS methods used for analysing mobility, accessibility and ordering of the landscape

Several GIS approaches for analysing mobility and accessibility patterns, and hence also telling about the ordering and perception of landscape (e.g. Llobera et al. 2011) are being applied in the analyses of the Khanuy Valley data. All the analyses are based on freely available GIS datasets. For instance, the movement analyses are built on the basis of 30 m cell size Aster digital elevation model (original data of ASTER GDEM is the product of METI and NASA). Aster GDEM was pre-processed for the analyses, and filtered at a few locations with the digitized topographic map contours to repair some observed inconsistencies. Spatial analyses were carried out using ArcGIS and GRASS GIS software; GRASS GIS includes some more powerful algorithms, e.g. for analysing catchment areas, such as so-called 'Knight's move' (Awaida et al. 2006, Wheatley and Gillings 2002: 143–4).

Cost surface modelling and used impedances

Accessibility modelling is founded on the cost surface analysis, on measuring the cumulative cost of getting from an opening location to other point(s); most often this is done by modelling the time or energy needed for traversing the landscape (e.g. Wheatley and Gillings 2002: 137–41). Models were created using Waldo Tobler's (1993) 'hiking function', which recognizes the effect of slope direction on the movement, whether going uphill or downhill (Tripcevich 2007: 16; see also Fábrega-Álvarez and Parcero-Oubiña 2007):

Walking velocity (km/hr) = 6 exp (-3.5 * abs (S + 0.05)) (1)
Where S = slope in degrees

The inverse relationship between energy expenditure and travel speed is illustrated in Figure 5.6 (based on Llobera 2000, Tobler 1993; also e.g. Herzog 2010, Murrieta-Flores 2010, Zakšek et al. 2008). This was used as the basis for reconstructing movement both on foot and on horseback (Tobler 1993: figure II).

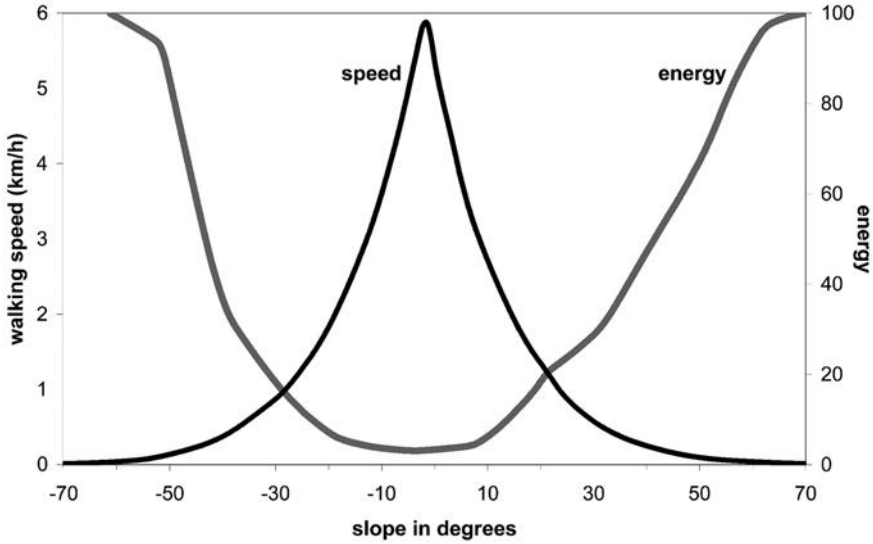

Figure 5.6 Relationship of energy expenditure and travel speed depending on the slope angle (energy expenditure based on Llobera 2000 [after Minetti 1995], travel speed on Tobler 1993: Figure II)

Besides topography, soil type and rivers were also taken into account in the movement models: the seasonally marshy, uneven floodplain was given 2.5 times the impedances than the more even and compact terrain types get (Murrieta-Flores 2010) and perennial rivers got four times the impedances. Rivers are passable at least on horseback at most places throughout the year, and therefore modelling of fords was not seen as necessary. However, it must be remembered that in the winter the rivers are frozen, being thus no obstacles at all, and then again especially during spring floods caused by snowmelt they might be temporarily impassable. These uncertainties have to be recognized in the analyses: in the future we are going to model accessibility separately for different times of the year to test the effect of seasonal changes. Only monuments situated within 45 minutes travel time from the areas systematically surveyed for occupation material were taken into account in the mobility and accessibility modelling, to avoid unwanted edge-effects.

Potential path areas and least-cost corridors

Accessibility and mobility analyses are based theoretically around time-geographical patterns analysing potential movement costs and directions, namely the potential path areas of space-time prisms from different starting points in the landscape (Figures 5.2, 5.7). Movement between locations was modelled based on

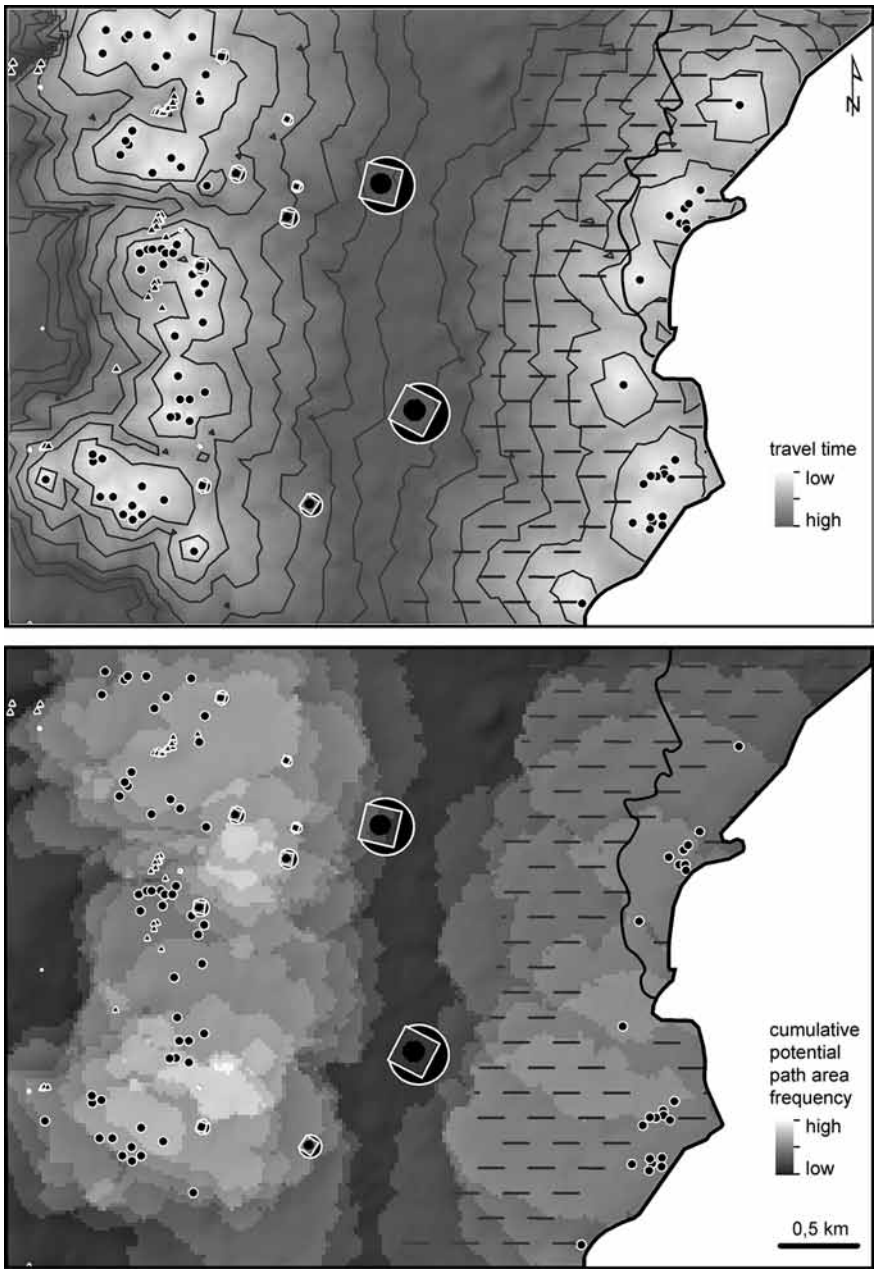

Figure 5.7 Top: Travel time from Bronze Age find locations (30 minute time-budget, 5 minute PPAs shown as solid lines); Bottom: 30 minute cumulative PPAs from same locations in the survey Area A

Source: Illustration by O. Seitsonen 2012.

potential least-cost movement corridors rather than as exact least-cost pathways. Several authors have noted (e.g. Fábrega-Álvarez and Parcero-Oubiña 2007, Gietl et al. 2008, Herzog 2010, Howey 2011, McRae et al. 2008, Neutens et al. 2010, Phillips et al. 2008, Zakšek et al. 2008) that the outputs of least-cost path models are more sensitive to used algorithms and input values than least-cost corridor analyses theoretically based on the time-geographical potential path area modelling.

Least-cost corridors were also modelled over a wider landscape than the surveyed areas presented in Figure 5.1, covering an area of about 200 by 150 km within which are situated all the mapped khirigsuur clusters in the Khanuy Valley (see Houle 2009a: 124). These were modelled as potential path areas from start and end points situated at one kilometre intervals ten kilometres outside the edges of the used study area, to avoid edge effects (see Whitley and Burns 2008). PPAs covering this area highlight the courses of most likely least-cost corridors crossing the landscape from all directions, which can be helpful for interpreting and identifying potential mobility and contact networks in a wider landscape context.

Visibility and movement

Besides topography and terrain characteristics, visibility should also be taken into account when analysing the structured arrangement of landscape and movement within it (e.g. Llobera 2001, Murrieta-Flores 2010, Wheatley and Gillings 2002: 181). Visual aspects become especially obvious when moving through a monumental landscape, for instance amongst khirigsuurs and slope burials (e.g. Wright 2006: 215, 2007). In this stage of analyses the inter-visibility between archaeological features and total viewshed (see e.g. de Montis and Caschili 2012, Llobera 2003, Llobera et al. 2010) within survey area A have been studied to assess what effects visibility might have had on the mobility and placement of sites. In future analyses these issues will be further studied by binding the movement and visibility more closely together, based on e.g. the topographic and visual prominence (e.g. Llobera 2001) and the effects visibility has while moving within the least-cost corridors (e.g. Bell and Lock 2000, Zakšek et al. 2008).

When examining visibility and viewsheds several pragmatic issues have to be taken into account, for instance how clearly visible a feature is, from which distance it can be observed, the effects of (palaeo-)vegetation and environment, and the reciprocity of fields of view (e.g. Murrieta-Florez 2010, Ogburn 2006, Wheatley and Gillings 2000). In the case of khirigsuurs, their height and bulk makes them prominent and visible in the landscape, and their peaks are visible from locations where their surrounding land surface is not; in other words, the visibility is not always reciprocal (e.g. Gillings and Wheatley 2001, Lock and Harris 1996, Wheatley 1995, Wheatley and Gillings 2000). In Khanuy Valley inter-visibility was examined by giving the DEM cells with khirigsuurs a height according to the included khirigsuur when analysing visibility *towards* these locations, whereas when analysing visibility *from* these locations the conditional observer eyesight height was used (1.7 m above the DEM), as at other locations; if a khirigsuur in a

cell is lower than 1.7 m, then the observer height was used instead. Of course, if one would climb on the top of a five meters tall khirigsuur, the field-of-view will become noticeably extended, but considering their probable ritual significance, this seems very unlikely in the past. On the other hand, for slope burials their obscurity against the rocky backgrounds and relative invisibility from further distance has to be acknowledged in the analyses. On the basis of empirical experience we limited their visibility in analyses within one kilometre, whereas for the other features used maximum viewing distance was three kilometres (e.g. Bell and Lock 2000).

Results of GIS visibility analyses were also partly assessed in the field to detect possible defects in DEM accuracy: based on the field evaluations the processed Aster GDEM is accurate enough for analysing the Khanuy Valley visual landscape. Still, it must be remembered that visual perception is culturally conditioned and highly dependent on the viewer's personal experience (e.g. Murrieta-Florez 2010, Ogburn 2006, Wheatley and Gillings 2000).

Mobility and accessibility in the Late Bronze Age Khanuy Valley

Mobility and accessibility in the Khanuy Valley is being assessed in the analyses at two scales, first on a local level, concentrating in the survey area A, and then in its wider landscape context. For the local level studies, seasonal mobility pattern has been interpreted as a tethered mobility one discussed above, migrating between the winter camps in the foothills and summer camps by the river. Although no surveys for locating settlement sites outside our survey areas have been carried out thus far, the core areas of these might be presented by the other khirigsuur clusters within the Khanuy Valley.

Local landscape context: Settlements and monuments

At the local level we examined the extent to which the monumental setting might have ordered settlement site location and seasonal mobility patterns by accessibility and visibility analyses. At this stage of the research we have examined the accessibility patterns for different kinds of monumental sites from the potentially contemporary occupation areas. Potential path areas (Figure 5.7) were modelled to scrutinize the travel times towards different monumental sites. Also cumulative potential path areas (Figure 5.7) have been modelled to give guidance of the circumstances mobility and time-budgeting allow for potential interaction and avoidance in the settlement landscape (see Mlekuz forthcoming).

As seen from Figure 5.4, there is a close association between occupation areas and slope burials based on the Euclidean distance (N=36, Euclidean distance 70–400 m, mean 195 m, s.d. 60 m). Then again, the khirigsuurs are consistently situated further away from domestic settings: the smaller khirigsuurs at the mouths of the valley draws (N=11, Euclidean distance 71–810 m, mean 360 m, s.d. 250 m) and the large ones on the edge of flood plain (N=2, Euclidean

distance 1130–1360 m, mean 1240 m) (see Houle 2009a, 2010). However, when the travel times from the occupation areas are modelled, the slope burials are situated temporally further away from the settlements than they are physically and visually, being often situated uphill from them in a rugged landscape (Figure 5.8).

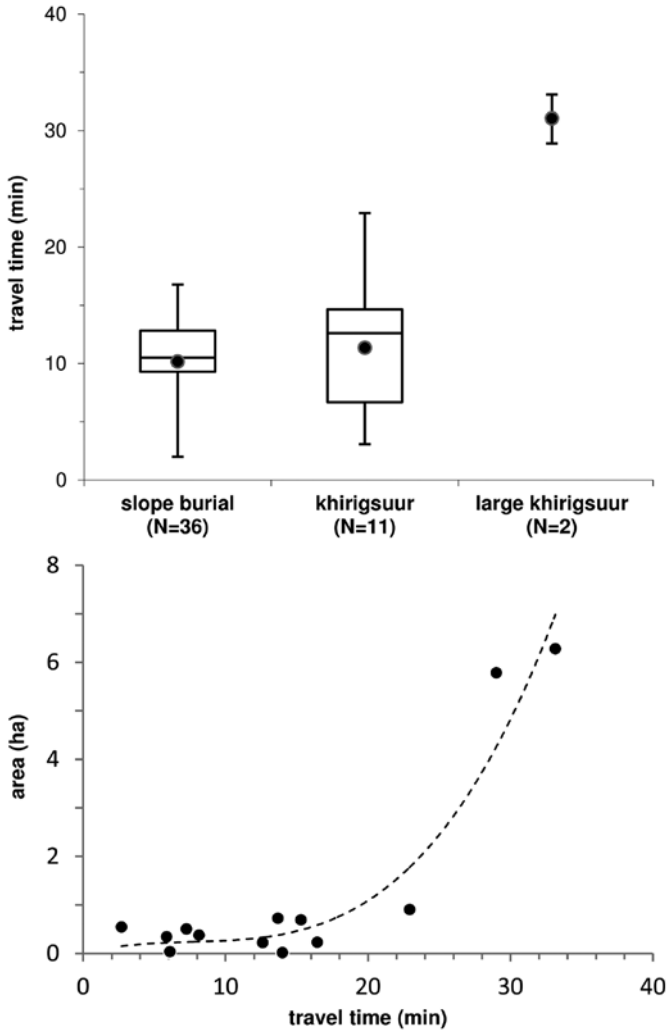

Figure 5.8 Top: Cost-distance travel times from the Bronze Age occupation areas to monumental sites; Bottom: Correlation between the cost-distance travel time and area covered by the khirigsuur's fence in the survey area A

Both small and large khirigsuurs are consistently further away from occupation areas than the slope burials, based on both the Euclidean distance and travel time. We further tested the correlation between travel times and area covered by khirigsuurs' fences (Figures 5.4, 5.8): khirgsuurs covering larger areas are consistently situated further away from the contemporary settlement. Perhaps the smaller khirigsuurs, situated in many cases in the mouths of valleys where the presumed winter camps are situated, have had closer ties to the domestic sites than the larger ones situated further away from them (see Figure 5.4).

We are also examining the visibility of various archaeological features: at this stage of analyses with inter-visibility between the occupation areas and other features (e.g. Gaffney and Stančič 1991: 78, Wheatley 1995), and with a total viewshed from each cell in the study area (Llobera 2003, Llobera et al. 2010, *c.f.* Lock and Harris 1996, field-of-view). Inter-visibility between settlements and both khirigsuurs and slope burials are clearly higher compared to the background: there is always at least one khirigsuur visible from every Bronze Age occupation area, and also at least one slope burial from the presumed winter camps situated less than one kilometre from them (Figure 5.9). The monumental landscape seems to have mirrored the seasonal mobility and possibly provided guidance for the placement of occupation areas: both distance between settlements and monuments and visual connections between them have affected the pattern(s).

Total viewshed analysis suggests that settlements, khirigsuurs, and especially slope burials have been placed at locations with higher visibility *from* them than what the background landscape has (Figure 5.9). Thus it seems that besides being directed by the connections to the monumental landscape, such as inter-visibility and distance, seasonal mobility and placement of settlement and monumental sites has also been directed by the size of viewshed opening from them to the surroundings.

Perhaps the khirigsuurs and slope burials have been acting as regional landscape markers, khirigsuurs as larger and more prominent markers, having a higher visibility from distance, with slope burials being situated at locations with higher visibility from them, and maybe marking more closely the occupation areas. At least some of the slope burials might have been more noticeable in the past when they were still carefully constructed and intact, and perhaps standing out better from their surroundings; the human eye has been described to potentially notice very small changes, e.g. as little as two per cent variations in brightness (Murrieta-Flores 2010, Ogburn 2006). Also seasonal occupation areas might have been more visually obvious in the past; at least nowadays the pastoralist winter camps in the foothill zone are clearly marked by the dark scars of livestock faeces piles and, when occupied, by the stark white gers (yurts).

At the local level it seems that the monumental landscape has given order and guided seasonal mobility patterns in the Khanuy Valley. Besides the practical characteristics affecting settlement site placement, such as the existence of level ground and adjacent good pastures, the visual contact with contemporaneous monuments also appears to have been a factor taken into account, as well as the

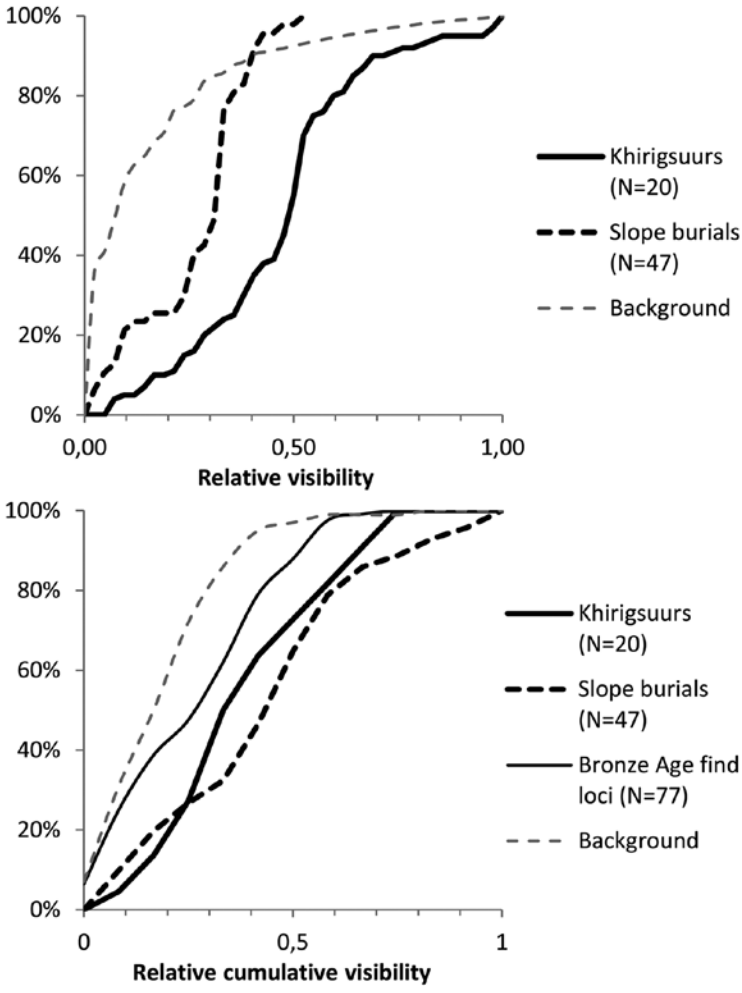

Figure 5.9 Top: Inter-visibility (standardized to 0–1) of monuments from the Bronze Age occupation areas; Bottom: Total viewshed (standardized to 0–1) from different archaeological features in the survey area A

distance from them. However, it must be remembered that several of the later Iron Age sites and modern pastoralist camps share the same locations, so the pragmatic aspects for the placing of settlements seem to have remained roughly analogous through time. On the other hand, this might mean that the Bronze Age settlement site distribution, based primarily on practical concerns, might have influenced the placement of monuments in the landscape, so that they are visible from those localities.

Bronze Age settlement sites are also situated at locations with higher visibility to their surroundings than the background environment has, providing visual control and dominance of the surroundings (*c.f.* Hamilton et al. 2006), over the grazing grounds and pathways in the valley. Slope burials seem to have had close ties to the occupation areas and might have functioned socially as family or kinship burial sites, as well as possibly marking domestic locations in the landscape. Perhaps also the smaller khirigsuurs situated on the plain, often at the mouths of the valley draws below the occupation areas (Figure 5.4), might have been associated with the family or kinship groups. Conversely, the larger khirigsuurs might have acted as stages for communal rituals, and especially the largest ones KYR-1 and KYR-40, based on the vast labour contribution put into their construction, might have been symbols of cooperation and social ties of supra-local groups. This was further examined by modelling mobility and accessibility potential on a supra-local level.

Wider landscape context: Monument clusters

In the wider landscape context we are testing the above presented hypothesis that the large khirigsuurs KYR-1 and KYR-40 represent and symbolize the combined efforts of social groups extending beyond the local level. Accessibility to these khirigsuurs was modelled as PPAs based on Tobler's (1993: figure II) suggestion for horseback travel (travel speed 5/4 times that on foot) and ethnographic evidence of horseback travel distances (also Minetti 2003; Figure 5.10). Modelled distances mirror those given by Minetti (2003) in his research on horse biomechanics and equine postal systems. Travel times of course become longer, if movement of pack animals or livestock is also involved (e.g. Tripcevich 2007: 165–7, 2008). However, modern pastoralists in Mongolia can cover distances up to 100 km in four days with herders on horseback tending their livestock (Broderick, field notes, 2012), although the families and household paraphernalia nowadays often travel on a truck that then waits for the riders at overnighting camps (personal observation).

Cumulative least-cost corridor PPAs are modelled in Figure 5.10 over the whole area (defined from the start and end points outside the study area as described above). Accumulation of least-cost corridors illustrates markedly how the potential travel routes 'bundle' (in time-geographical terminology) within Khanuy Valley and the neighbouring valleys, emphasizing their potential importance as passages in the past mobility system(s) in a wider landscape scale.

Travel time modelling proposes that the khirgsuur clusters in Khanuy Valley are consistently situated roughly one day's horseback travel distance from each other. Least-cost corridor modelling suggests that the clusters are also situated adjacent to crossroads of several potential travel routes from different directions. These observations give support for the current interpretation based on Khanuy surveys that dense monumental clusters could correlate with centralized settlement (Houle 2009a, 2010), situated at locations with good access to potential pathways to several directions. Different clusters are within a reasonable distance from each other, and from the largest khirigsuurs, which could support the idea of these as

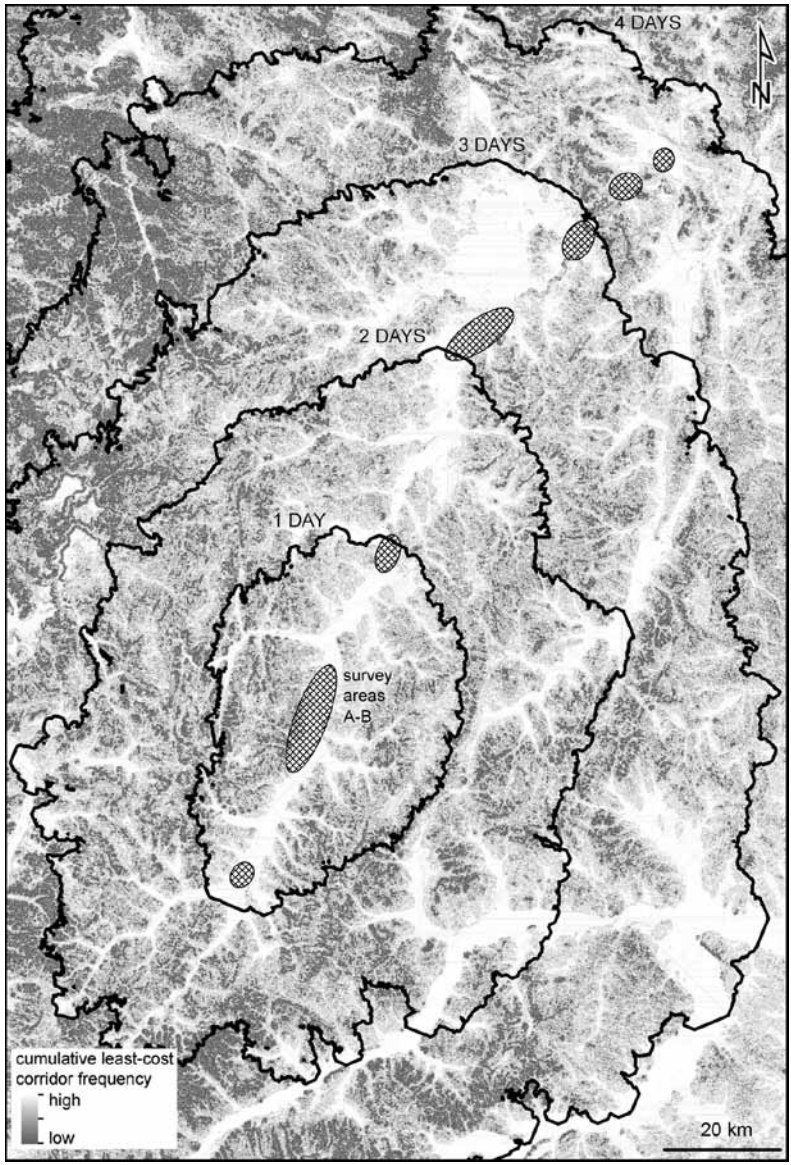

Figure 5.10 Khirigsuur clusters in Khanuy Valley (dashed line), the intervals of one day PPAs (solid line) from the largest KYR-1 and KYR-40 khirigsuurs, and modelled cumulative least-cost corridors across the landscape

Source: Illustration by O. Seitsonen 2012.

symbols and scenes of supra-local interaction. Perhaps inter-group social ties were conveyed and re-negotiated at these locations, which might have materialized under combined spiritual (shamanistic) and political authority (Houle 2009a; *c.f.* Jagchid and Hayer 1979: 171). Social status, perhaps even hereditary rank, might have been partly based on the ability to build and maintain these long-distance contact networks (Houle 2010: 185).

Modelled accessibility to the largest khirigsuurs could also be used in a predictive manner, suggesting potential survey areas in the neighbouring valleys east and west of Khanuy. The nearest valleys are accessible from the largest khirigsuurs through the mountain passes within the same time-budget as the closest khirigsuur clusters north and south in Khanuy Valley, through one day's horseback travel (Figure 5.10). In future studies it would be interesting to survey for settlement sites both around the other khirigsuur clusters in Khanuy and in the neighbouring valleys, as perhaps all of these could have been parts of the same complex supra-local social network, materialized and symbolized with the immense ritual monuments such as KYR-1 and KYR-40 and the deer stone complex of Jargalantyn Am.

Further GIS analyses based on time-geography which have relevance for reconstructing mobility and accessibility patterns are, for example, the modelling of potential path fields (Figure 5.11; *c.f.* Mlekuz forthcoming) visualizing how far one can reach from each cell within an allocated time-budget, reminiscent of the total viewshed as defined by Llobera (2003). These can be further analysed (e.g. with prominence filters – Llobera 2001, Mlekuz forthcoming) to assess the relative accessibility of various portions of the landscape.

Prominence figures show plainly how the used analytical scale affects results and interpretations: it is often necessary to examine outcomes of GIS analyses at various scales to achieve wider perception of the studied situation (see Llobera 2000, 2001, also João 2002, for a non-archaeological example). At all scales khirigsuurs (shown as dots in Figure 5.11) and Bronze Age occupation areas down by the river, interpreted as summer camps, are situated at areas of higher accessibility potential. Then again the occupation areas in the valley draws of the foothills, interpreted as winter camps, are situated at less approachable and more protected locations, as well as the slope burials located in the more rugged, uphill topography. Both the potential path field and prominence data also illustrate nicely how the khirigsuur clusters are situated at the crossroads of several least-cost corridors, i.e. potential past pathways.

Based on the various lines of evidence, the largest khirigsuurs might have acted as symbols of the unity and capacity of a larger intertwined community network over a larger area for both the locals and outsiders passing via Khanuy Valley. They were probably settings for centralized, recurring communal rituals where the social ties as well as long-distance alliances between groups were moulded and re-negotiated (see Honeychurch 2004, Houle 2009a, 2010: 189, Wright 2007). As Houle (2010: 185) has proposed, perhaps wide-ranging contact networks were also vital for social status building, e.g. through acquisition of foreign goods, and

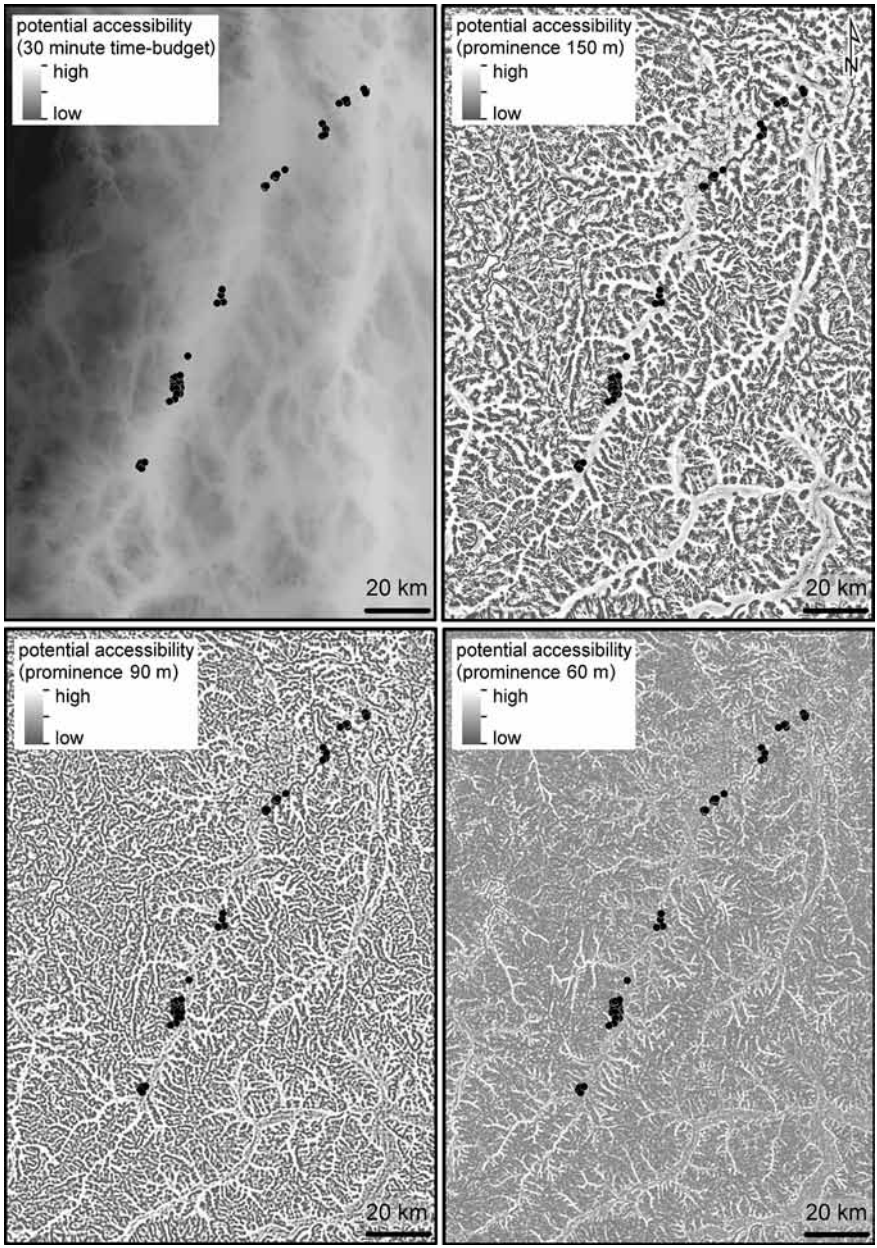

Figure 5.11 Top left: 30 minute potential path field; Top right: its prominence at 150 meter radius; Bottom left: its prominence at 90 meter radius; Bottom right: its prominence at 60 meter radius; khirigsuurs recorded during the roadside survey marked with dots

Source: Illustration by O. Seitsonen 2012.

might have provided one opportunity for the development of hereditary leadership and social complexity.

Epilogue

In this chapter we have discussed the potential uses of time-geography (Hägerstrand 1970) for studying archaeological mobility, and described on-going analyses of past movement and accessibility patterns in the Khanuy Valley, Mongolia during the Late Bronze Age. Time-geography provides a solid theoretical and methodological framework for approaching issues related to human movement and mobility in time and space, building on a strong set of empirical restrictions set by the physical environment and other features, as well as also exhibiting potential to assess human behavioural needs and culturally idiosyncratic and interpretative aspects (e.g. Mlekuz forthcoming, Murrietta-Florez 2010).

In our Khanuy Valley case study the imposing monumental landscape seems to have ordered and channelled the seasonal mobility pattern(s) on the local level. Seasonal mobility has been interpreted on the basis of excavations and surveys, as well as ethnographic analogies, as one of tethered mobility, with potential winter camps in the protected valley draws in the foothills and summer camps along the river and its floodplain. Distance from and inter-visibility with different kinds of sites seems to have affected the placement of both the settlement and monumental sites in the landscape, besides more practical environmental and economic aspects connected to settlement site placing, such as topography and livelihood constraints. As mentioned above, since many of the Bronze Age settlement sites have been used during later prehistory, and some even today, perhaps the good and practical settlement sites provided guidance for placement of the monuments as markers in the landscape.

Possibly, monuments also affected mobility on a wider level, perhaps for seasonal gatherings for communal celebrations at sites such as the largest khirigsuurs, which demonstrably exhibit labour input beyond the scope of a local social unit. Khirigsuur clusters in the Khanuy Valley are situated within reasonable horseback travel distance from each other, and from the largest khirigsuurs. Also the valleys to the east and west are reachable through the mountain passes within a comparable time-budget, so correspondingly these areas might have formed part of the same supra-local social network. Perhaps the foundations of social complexity, observable in the following Iron Age times, lie in developments during the late Bronze Age, such as the possible establishment of hereditary spiritual or political leadership status and supra-local social ranking (e.g. Erdenebaatar 2002, Houle 2009a, 2010). Current hypotheses and other issues of mobility and accessibility will be further elaborated in the on-going studies.

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References

Allard, F. and Erdenebaatar D. 2005. Khirigsuurs, ritual and mobility in the Bronze Age of Mongolia. *Antiquity*, 79, 547–63.

Allard, F., Erdenebaatar, D. and Houle, J.-L. 2006. Recent archaeological research in the Khanuy River Valley, Central Mongolia, in *Beyond the Steppe and the Sown: Proceedings of the 2002 University of Chicago Conference on Eurasian Archaeology*, edited by D.L. Peterson, L.M. Popova and A.T. Smith. Leiden and Boston: Brill Academic Publishers, 202–24.

Awaida, A., Westerwelt, J. and de Mouveaux, P. 2006. *r.cost*. [Online]. Available at: http://grass.osgeo.org/gdp/html_grass63/r.cost.html [accessed: 12 November 2010].

Bayarsaikhan, J. 2005. Shamanistic elements in Mongolian deer stone art, in *The Deer Stone Project: Anthropological Studies in Mongolia 2002–2004*, edited by W. Fitzhugh. Washington, D.C. and Ulaanbaatar: Arctic Studies Center, National Museum of Natural History, Smithsonian Institution and National Museum of Mongolian History, 41–5.

Bayarsaikhan, J. 2011. Brief introduction of the Mongolian deer stone culture, in *Deer Stones of the Jargalantym Am*, edited by Ts. Turbat and J. Bayarsaikhan. Ulaanbaatar: Mongolian Tangible Heritage Association NGO, 18–43.

Bazargür, D. 2005. *Belcheeriin Mal Azh Akhuin Gazarzüi* [Geography of Pastoral Animal Husbandry]. Ulaanbaatar: Mongolian Academy of Science, Institute of Geography.

Bell, T. and Lock, G.R. 2000, Topographic and cultural influences on walking the Ridgeway in later prehistoric times, in *Beyond the Map: Archaeology and Spatial Technologies*, edited by G.R. Lock. Amsterdam: IOS Press (NATO Science Series A: Life Sciences, 321), 85–100.

Bender, B. 1993. Cognitive archaeology and cultural materialism. *Cambridge Archaeological Journal*, 3(2), 257–60.

Birkett, C. 1985. A site catchment analysis: Walkunder Arch Cave, near Chillagoe, North Queensland. *Queensland Archaeological Research*, 2, 132–43.

Bradley, R. 1991. Monuments and places, in *Sacred and Profane. Proceedings of a Conference on Archaeology, Ritual and Religion, Oxford 1989*, edited by P. Garwood, R.S. Jennings, R. Skeates and J. Toms. Oxford: Oxford University Committee for Archaeology (Monograph 32), 135–40.

Carballo, D.M. and Pluckhahn, T. 2007. Transportation corridors and political evolution in Highland Mesoamerica: Settlement analyses incorporating GIS for Northern Tlaxcala, Mexico. *Journal of Anthropological Archaeology*, 26(4), 607–29.

Chisholm, M. 1968. *Rural Settlement and Land Use: An Essay in Location*. London: Hutchinson.

Clark, J.E. and Blake, M. 1994. The power of prestige: Competitive generosity and the emergence of rank societies in Lowland Mesoamerica, in *Factional Competition and Political Development in the New World*, edited by E.M. Brumfield and J.W. Fox. Cambridge: Cambridge University Press, 17–30.

Erdenebaatar, D. 2000. *Bulgan Aimagiin Khutag*- Öndör *sumyn Khantai bagiin nutag Egiin Golyn khöndiid iavuulsan etnografi in ekspeditsiin sudalgaany tailan* [Research report of the ethnographic expedition to the Egiin Gol valley of Khantai baga, Khutag-Ondor sum, Bulgan Province]. Unpublished field report. Ulaanbaatar: Ulaanbaatar University, Department of Archaeology and Ethnology.

Erdenebaatar, D. 2002. *Mongol Nutgiin dakh' dörvölzhin bulsh khirigsüüriin soel* [The Four Sided Grave and Khirigsuur Cultures of Mongolia]. Ulaanbaatar: Mongolian Academy of Sciences, Institute of History.

Erdenebaatar, D. 2004. Burial materials related to the history of the Bronze Age in the Territory of Mongolia, in *Metallurgy in Ancient Eastern Eurasia from the Urals to the Yellow River*, edited by K. M. Linduff. Lewiston: Edwin Mellen Press (Chinese studies 31), 189–223.

Fábrega-Álvarez, P. 2006. Moving without destination. A theoretical GIS-based determination of movement from a giving origin. *Archaeological Computing Newsletter*, 64, 7–11.

Fábrega-Álvarez, P. and Parcero-Oubiña, C. 2007. Proposals for an archaeological analysis of pathways and movement. *Archaeologia e Calcolatori*, 18, 121–41.

Fitzhugh, W. 2005. *The Deer Stone Project: Anthropological Studies in Mongolia 2002–2004*. Washington, D.C. and Ulaanbaatar: Arctic Studies Center, National Museum of Natural History, Smithsonian Institution and National Museum of Mongolian History.

Fitzhugh, W. 2009. Pre-Scythian Bronze Age ceremonialism and art in Northern Mongolia, in *Social Complexity in Prehistoric Eurasia: Monuments, Metals and Mobility*, edited by B.K. Hanks and K.M. Linduff. Cambridge: Cambridge University Press, 378–411.

Foley, R.A. 1981. *Off-Site Archaeology and Human Adaptation in Eastern Africa: An Analysis of Regional Artefact Density in the Amboseli, Southern Kenya*. Oxford: British Archaeological Reports (BAR International Series 97/ Cambridge Monographs in African Archaeology 3).

Forer, P., Huisman, O. and McDowall, C. 2007. Dynamic prisms and 'instant access': linking opportunities in space to decision making in time, in *Societies and Cities in the Age of Instant Access*, edited by H.J. Miller. Berlin: Springer (The Geojournal Library, 88), 119–32.

Gaffney, V. and Stančič, Z. 1991. *GIS Approaches to Regional Analysis: A Case Study of the Island of Hvar*. Ljubljana: Znanstveni Inštitut Filozofske Fakultete.

Gaffney, V., Stančič, Z. and Watson, H. 1996. Moving from catchments to cognition: Tentative steps towards a larger archaeological context for GIS, in *Anthropology, Space, and Geographic Information Systems*, edited by M. Aldenderfer and H.D.G. Maschner. New York: Oxford University Press, 132–54.

Gietl, R., Doneus, M. and Fera, M. 2008. Cost distance analysis in an alpine environment: Comparison of different cost surface modules, in *Layers of Perception. Proceedings of the 35th International Conference on Computer Applications and Quantitative Methods in Archaeology (CAA), Berlin, Germany, April 2–6, 2007*, edited by A. Posluschny, K. Lambers and I. Herzog. Bonn: Dr. Rudolf Habelt GmbH (Kolloquien zur Vor- und Frühgeschichte 10), 342–50.

Gillings, M. and Wheatley, D. 2001. Seeing is not believing: Unresolved issues in archaeological visibility analysis, in *On the Good use of Geographical Information Systems in Archaeological Landscape Studies. Proceedings of the COST G2 Working Group 2 round table Luxembourg*, edited by B. Slapšak. Luxembourg: Office for Official Publications of the European Communities, 25–36.

Hägerstrand, T. 1970. What about people in regional science? *Papers of the Regional Science Association*, 24, 7–21.

Hägerstrand, T. 1973. The domain of human geography, in *Directions in Geography*, edited by R.J. Chorley. London: Methuen, 67–87.

Hägerstrand, T. 1975. Space, time and human conditions, in *Dynamic Allocation of Urban Space*, edited by A. Karlqvist, L. Lundqvist and F. Snickars. Farnborough: Saxon House Lexington Book, 3–12.

Hägerstrand, T 1989. Reflections on 'what about people in regional science?' *Papers in Regional Science*, 66(1), 1–6.

Hamilton, S., Whitehouse, R., Brown, K., Combes, P., Herring, E. and Thomas, M.S. 2006. Phenomenology in practice: Towards a methodology for a 'subjective' approach. *European Journal of Archaeology*, 9, 31–71.

Harmsworth, G. 1998. Indigenous values and GIS: A method and a framework. *Netherlands organisation for international cooperation in higher education, Nuffic*, [Online], 6(3). Available at: http://www.landcareresearch.co.nz/research/sustainablesoc/social/ikdmpap.asp [accessed: 23 September 2011].

Hayden, B. 1995. Pathways to power: Principles for creating socioeconomic inequalities, in *Foundation of Social Inequality*, edited by T.D. Price and G. Feinman. New York: Plenum, 15–85.

Herzog, I. 2010. Theory and practice of cost functions, in *Fusion of Cultures. Abstracts of the XXXVIII Conference on Computer Applications and Quantitative Methods in Archaeology, CAA2010, Granada*, edited by F.J. Melero, P. Cano and J. Revelles. Granada: Annual Conference on Computer Applications and Quantitative Methods in Archaeology, 431–4.

Higgs, E.S. 1975. *Palaeoeconomy*. London: Cambridge University Press.

Hodder, I. and Orton, C. 1976. *Spatial Analysis in Archaeology*. Cambridge: Cambridge University Press.

Honeychurch, W.H. 2004. *Inner Asian Warriors and Khans: A Regional Spatial Analysis of Nomadic Political Organization and Interaction*. Unpublished Ph.D. Dissertation, University of Michigan.

Houle, J.-L. 2009a. Investigating mobility, territoriality and complexity in the Late Bronze Age: An initial perspective from monuments and settlements, in *Current Archaeological Research in Mongolia. Papers from the First International Conference on 'Archaeological Research in Mongolia'*, edited by J. Bemmann, H. Parzinger, E. Pohl, and D. Tseveendorj, Bonn: Bonn Contributions on Asian Archaeology 4, 117–34.

Houle, J.-L. 2009b. 'Socially Integrative Facilities' and the Emergence of Societal Complexity on the Mongolian Steppe, in *Social Complexity in Prehistoric Eurasia: Monuments, Metals and Mobility*, edited by B.K. Hanks and K.M. Linduff. Cambridge: Cambridge University Press, 358-377.

Houle, J.-L. 2010. *Emergent Complexity on the Mongolian Steppe: Mobility, Territoriality, and the Development of Early Nomadic Polities*. Unpublished PhD. thesis, University of Pittsburgh.

Houle, J.-L. and Broderick, L.G. 2011. Settlement patterns and domestic economy of the Xiongnu in Khanui Valley, Mongolia, in *Xiongnu Archaeology: Multidisciplinary Perspectives of the First Steppe Empire in Central Asia, Bonn Contributions to Asian Archaeology 5*, edited by U. Brosseder and B.K. Miller. Bonn: Rheinische Friedrich-Wilhelms-Universität Bonn, 137–52.

Howey, M.C.C. 2007. Using multi-criteria cost surface analysis to explore past regional landscapes: A case study of ritual activity and social interaction in Michigan, AD 1200–1600. *Journal of Archaeological Science*, 34, 1830–46.

Howey, M.C.L. 2011. Multiple pathways across past landscapes: Circuit theory as a complementary geospatial method to least cost path for modelling past movement. *Journal of Archaeological Science*, 38, 2523–35.

Huisman, O., Santiago, I.F., Kraak, M.-J. and Retsios, B. 2009. Developing a geovisual analytics environment for investigating archaeological events: Extending the space-time cube. *Cartography and Geographic Information Science*, 36(3), 225–36.

Jagchid, S. and Hayer, P. 1979. *Mongolia's Culture and Society*. Boulder: Westview Press.

Jerpåsen, G.P. 2012. Application of visual archaeological landscape analysis: Some results. *Norwegian Archaeological Review*, 42(2), 123–45.

João, E. 2002. How scale affects environmental impact assessment. *Environmental Impact Assessment Review*, 22(4), 289–310.

Koryakova, L.N. 1996. Social trends in temperate Eurasia during the second and first millennia BC. *Journal of European Archaeology*, 4, 243–80.

Kraak, M.-J. 2003. The space–time cube revisited from a geovisualization perspective, in *Cartographic Renaissance, Proceedings of the 21st*

International Cartographic Conference (ICC2003), 10–16 August 2003, Durban, South Africa, 1988–1996 [Online] Available at: http://www.itc.nl/library/Papers_2003/art_proc/kraak.pdf [accessed: 18 April 2012].

Kraak, M.-J., and Huisman. O. 2009. Beyond exploratory visualization of space–time paths, in *Geographic Data Mining and Knowledge Discovery*, edited by H.J. Miller and J. Han. London: Taylor and Francis, 431–43.

Kraak, M.-J., and Koussoulakou. A. 2004. A visualization environment for the space–time cube, in *Advances in Spatial Data Handling II, Proceedings of the 11th International Symposium on Spatial Data Handling (SDH2004), August 23–25, 2004, University of Leicester*, edited by P.F. Fisher. Berlin: Springer, 189–200.

Kvamme, K.L. 1985. Determining empirical relationships between the natural environment and prehistoric site locations: A hunter gatherer example, in *For Concordance in Archaeological Analysis: Bridging Data Structure, Quantitative Technique, and Theory*, edited by C. Carr. Kansas City: Westport Publishers, 208–38.

Kvamme, K.L. 1999. Recent directions and developments in geographical information systems. *Journal of Archaeological Research*, 7(2), 153–202.

Kwan, M.-P. and Lee, J. 2004. Geovisualization of human activity patterns using 3D GIS: A time-geographic approach, in *Spatially Integrated Social Science: Examples in Best Practice*, edited by M.F. Goodchild and D.G. Janelle. Oxford: Oxford University Press, 48–66.

Lee, R.B. 1969. !Kung Bushman subsistence: An input output analysis, in *Environment and Cultural Behaviour*, edited by A.P. Vayda. New York: Natural History Press, 47–79.

van Leusen, P.M. 2002. *Chapter 6. Line-of-sight and Cost Surface Analysis Using GIS. Pattern to Process: Methodological Investigations into the Formation and Interpretation of Spatial Patterns in Archaeological Landscapes*. Unpublished PhD dissertation, Faculty of Arts, University of Groningen [Online]. Available at: http://dissertations.ub.rug.nl/FILES/faculties/arts/2002/p.m.van.leusen/ch6.pdf [accessed: 07 January 2007]

Llobera, M. 2000. Understanding movement: A pilot model towards the sociology of movement, in *Beyond the Map: Archaeology and Spatial Technologies*, edited by G.R. Lock. Amsterdam: IOS Press (NATO Science Series A: Life Sciences, 321), 65–84.

Llobera, M. 2001. Building past landscape perception with GIS: Understanding topographic prominence. *Journal of Archaeological Science*, 28, 1005–14.

Llobera, M. 2003. Extending GIS-based visual analysis: The concept of visualscapes. *International Journal of Geographical Information Science*, 17(1), 25–48.

Llobera, M., Wheatley, D., Steele, J., Cox, S. and Parchment, O. 2010. Calculating the inherent visual structure of a landscape (inherent viewshed) using high-throughput computing, in *Beyond the Artefact: Digital Interpretation of the Past: Proceedings of CAA2004, Prato, 13–17 April 2004*, edited by F. Niccolucci and S. Hermon. Budapest: Archaeolingua, 146–51.

Llobera, M., Fábrega-Álvarez, P. and Parcero-Oubiña, C. 2011. Order in movement: A GIS approach to accessibility. *Journal of Archaeological Science*, 38, 843–51.

Lock, G.R. and Harris, T.M. 1996. Danebury revisited: An English Iron Age hillfort in a digital landscape, in *Anthropology, Space, and Geographic Information Systems*, edited by M. Aldenderfer and H.D.G. Maschner. New York: Oxford University Press, 214–40.

Lock, G.R. and Harris, T.M. 2006. Enhancing predictive archaeological modelling: Integrating location, landscape and culture, in *GIS and Archaeological Site Location Modeling*, edited by M.W. Meher and K.L. Wescott. Boca Raton: Taylor and Francis, 36–55.

McRae, B.H., Dickson, B.G., Keitt, T.H. and Shah, V.B. 2008. Using circuit theory to model connectivity in ecology and conservation. *Ecology*, 10, 2712–24.

Miller, H.J. 1991. Modelling accessibility using space-time prism concepts within geographical information systems. *International Journal of Geographical Information Systems*, 5(3), 287–301.

Miller, H.J. 2005. What about people in geographic information science?, in *Re-Presenting Geographic Information Systems*, edited by P. Fisher and D. Unwin. London: John Wiley and sons, 215–42.

Minetti, A.E. 1995. Optimum gradient of mountain paths. *Journal of Applied Physiology*, 79, 1698–703.

Minetti, A.E. 2003. Efficiency of equine postal systems. *Nature*, 486, 785–6.

Mlekuz, D. (Forthcoming). Time geography, GIS and archaeology, in *Fusion of Cultures. Proceedings of the 38th Conference on Computer Applications and Quantitative Methods in Archaeology (CAA2010), Granada, Spain, April 2010*, edited by F. Contreras and F.J. Melero.

Montis, de A., Caschili, S. 2012. Nuraghes and landscape planning: Coupling viewshed with complex network analysis. *Landscape and Urban Planning*, 105(3), 315–24.

Murrieta-Flores, P.A. 2010. Travelling in a prehistoric landscape: Exploring the influences that shape human movement, in *Making History Interactive. Computer applications and quantitative methods in archaeology (CAA2009). Proceedings of the 37th international conference, Williamsburg, Virginia, USA, March 22–26, 2009*, edited by B. Frischer, J. Webb Crawford and D. Koller. Oxford: Archaeopress (BAR International Series 2079), 249–67.

Neutens, T., Versichele, M. and Schwanen, T. 2010. Arranging place and time: A GIS toolkit to assess person-based accessibility of urban opportunities. *Applied Geography*, 30, 561–75.

Ogburn, D.E. 2006. Assessing the level of visibility of cultural objects in past landscapes. *Journal of Archaeological Science*, 33, 405–13.

Orford, R. Dorling, D. and Harris, R. 1998. *Review of Visualization in the Social Sciences: A State of the Art Survey and Report. School of Geographical Sciences, University of Bristol, Report for the Advisory Group On Computer Graphics, Final Report 27th July 1998*. Bristol: University of Bristol. [Online] Available

at: http://sasi.group.shef.ac.uk/publications/reports/AGOCGreview_of_vis_in_soc_sci.pdf [accessed: 21 April 2012].

Phillips, S.J., Williams, P., Midgley, G. and Archer, A. 2008. Optimizing dispersal corridors for the Cape Proteaceae using network flow. *Ecological Applications*, 18, 1200–11.

Pred, A. 1977. The choreography of existence: Comments on Hägerstrand's time-geography and its usefulness. *Economic Geography*, 53, 207–21.

Pred, A. 1990. *Lost Words and Lost Worlds: Modernity and the Language of Everyday Life in Late Nineteenth-Century Stockholm*. Cambridge: Cambridge University Press.

Ridges, M. 2006. Regional dynamics of hunting and gathering: An Australian case study using archaeological predictive modeling, in *GIS and Archaeological Site Location Modeling*, edited by M.W. Meher and K.L. Wescott. Boca Raton: Taylor and Francis, 115–36.

Roper, D.C. 1979. The method and theory of site catchment analysis: A review. *Advances in Archaeological Method and Theory*, 2, 120–40.

Seitsonen, O. 2009. Prehistoric land–use in the Loita-Mara Region, Southwest Kenya: A preliminary GIS site catchment analysis. *Nyame Akuma*, 71, 46–53.

Tilley, C. 1994. *A Phenomenology of Landscape. Places, Paths and Monuments*. Oxford: Berg Publishers.

Tilley, C. 2004. *The Materiality of Stone: Explorations in Landscape Phenomenology*. Oxford: Berg Publishers.

Tobler, W. 1993. *Three Presentations on Geographical Analysis and Modelling. National Centre for Geographic Information and Analysis, Santa Barbara, Technical report 93–1*. [Online] Available at: http://www.ncgia.ucsb.edu/Publications/Tech_Reports/93/93–1.PDF [accessed: 20 March 2012].

Tripcevich, N. 2007. *Quarries, Caravans, and Routes to Complexity: Prehispanic Obsidian in the South-Central Andes*. Unpublished Ph.D. Dissertation, Department of Anthropology, University of California, Santa Barbara. [Online] Available at: http://mapaspects.org/tripcevich-phd-diss [accessed: 07 February 2009].

Tripcevich, N. 2008. *Llama Caravan Transport. A Study of Mobility with a Contemporary Andean Salt Caravan. 73rd Annual Meeting of the Society of American Archaeology, Vancouver, B.C., Canada*. [Online] Available at: http://works.bepress.com/tripcevich/7 [accessed: 13 April 2012].

Tsybiktarov, A.D. 1998. *Kul'tura plitochnykh mogil Mongolii i Zabaikal'ia* [Culture of the slab burials of Mongolia and Zabaikal'e]. Ulan-Ude: Nauka.

Vainhstein, S. 1980. *Nomads of South Siberia: The Pastoral Economies of Tuva*. Cambridge: Cambridge University Press (Cambridge Studies in Social Anthropology 25).

Vita-Finzi, C. and Higgs, E.S. 1970. Prehistoric economy in the Mount Carmel area of Palestine: Site catchment analysis. *Proceedings of the Prehistoric Society*, 36, 1–37.

Wallace, E. and Frohlich, B. 2005. Bronze Age burial mounds in Northern Mongolia: Use of GIS in identifying spatial and temporal variation, in *The Deer Stone Project: Anthropological Studies in Mongolia 2002–2004*, edited by W. Fitzhugh. Washington, D.C. and Ulaanbaatar: Arctic Studies Center, National Museum of Natural History, Smithsonian Institution and National Museum of Mongolian History, 89–98.

Whallon, R. 2006. Social networks and information: Non-'utilitarian' mobility among hunter-gatherers. *Journal of Anthropological Archaeology*, 25, 259–70.

Wheatley, D. 1993. Going over old ground: GIS, archaeological theory and the act of perception, in *Computing the Past: Computer Applications and Quantitative Methods in Archaeology, CAA92*, edited by J. Andresen, T. Madsen and I. Scollar. Aarhus: Aarhus University Press, 133–8.

Wheatley, D. 1995. Cumulative viewshed analysis: A GIS-based method for investigating intervisibility, and its archaeological application, in *Archaeology and Geographic Information Systems: A European Perspective*, edited by G.R. Lock and Z. Stančič. London: Taylor and Francis, 171–85.

Wheatley, D. 2004. Making space for an archaeology of place. *Internet Archaeology* [Online], 15. Available at: http://intarch.ac.uk/journal/issue15/wheatley_index.html [accessed: 14 June 2009].

Wheatley, D. and Gillings, M. 2000. Vision, perception and GIS: Developing enriched approaches to the study of archaeological visibility, in *Beyond the Map: Archaeology and Spatial Technologies*, edited by G. R. Lock. Amsterdam: IOS Press (NATO Science Series A: Life Sciences), 321, 1–27.

Wheatley, D. and Gillings, M. 2002. *Spatial Technology and Archaeology: The Archaeological Applications of GIS*. London: Taylor and Francis.

Whitley, T.G. and Burns, G. 2008. Conditional GIS surfaces and their potential for archaeological predictive modelling, in *Layers of Perception. Proceedings of the 35th International Conference on Computer Applications and Quantitative Methods in Archaeology (CAA), Berlin, Germany, April 2–6, 2007*, edited by A. Posluschny, K. Lambers and I. Herzog. Bonn: Dr. Rudolf Habelt GmbH (Kolloquien zur Vor- und Frühgeschichte) 10, 292–8.

Witcher, R.E. 1999. GIS and landscapes of perception, in *Geographic Information Systems and Landscape Archaeology*, edited by M. Gillings, D. Mattingly and J. van Dalen. Oxford: Oxbow Books, 13–22.

Wright, J. 2006. *The Adoption of Pastoralism in Northeast Asia: Monumental Transformation in the Egiin Gol Valley, Mongolia*. Unpublished PhD dissertation, University of Harvard.

Wright, J. 2007. Organizational principles of Khirigsuur monuments in the lower Egiin Gol valley, Mongolia. *Journal of Anthropological Archaeology*, 26, 350–65.

Wright, J. 2009. 'Unseen by eye, unheard by ear'. The archaeology of the early Türks at Baga Gazaryn Chuluu, in *Current Archaeological Research in Mongolia*, edited by J. Bemmann, H. Parzinger, E. Pohl and D. Tseveendorzh.

Bonn: Rheinische Friedrich-Wilhelms-Universität Bonn (Bonn Contributions to Asian Archaeology 4), 349–63.

Zakšek, K., Fovet, E., Nuninger, L. and Podobnikar, T. 2008. Path modelling and settlement pattern, in *Layers of Perception. Proceedings of the 35th International Conference on Computer Applications and Quantitative Methods in Archaeology (CAA), Berlin, Germany, April 2–6, 2007*, edited by A. Posluschny, K. Lambers and I. Herzog. Bonn: Dr. Rudolf Habelt GmbH (Kolloquien zur Vor- und Frühgeschichte 10), 309–15.

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Chapter 6
Micro Mobilities and Affordances of Past Places

Kirk Woolford and Stuart Dunn

Introduction

The careful excavation of physical evidence and examination of contexts and provenance allow us to make informed hypotheses about the physical construction and location of past structures. But is it possible to inform our understandings of how people moved around and through these structures? Is there any manner in which we can use the same physical evidence to infer how these structures were used? Can we apply understandings of how human perception informed past people about the meanings of environmental objects? Can we apply elements of experimental archaeology in an attempt to replicate past processes? Can we borrow from J.J. Gibson's theories of affordance or direct-perception (1979), where objects and events have inherent meaning detected and exploited by human beings without mental calculation to aid our understanding of past places? Do ecological approaches to embodiment and cognition help us to understand relationships between past peoples, their tools, their environments, and how all of these elements function together as a system? If human movements, or moving humans, are added to heritage reconstructions without consideration of how environment, artefact, perception, and action are linked, they become aesthetic adornments. However, if movement is captured and applied with rigour similar to that applied to the materials used for the reconstructions, the virtual models become more than sculptures and can more usefully reflect the activities and behaviours conjectured to have taken place in the location.

As an aid to understanding these links between sites and movement, it is useful to explore the UNESCO definition of Intangible Cultural Heritage. During development of the definition, the team looked at Dr Rangihiroa Panoho's example of the Marae, as simultaneously a building and a cultural meeting space for the Maori. It functioned along the lines of what Joseph Roach calls 'vortices of behaviour', which characterize churches, marketplaces, theatres, schools, and kitchens, i.e. places where certain kinds of behaviours and values are learned and certain memories are transmitted (Roach 1996: 26–8).

Another useful approach to understanding this issue comes from the philosophical construct of phenomenology, or of interpreting locations in terms of experience of them. Typically phenomenology has focused on the embodiment

of interpretation of locations-specific practices such as cult and religion, or the remediation of pathways through the landscape that are demarked by some extant physical structure, such as earthworks (see Tilley 1994, Copeland 2009). In a wide-ranging review of the subject in 2005, Joanna Brück noted:

> one of the most productive strands of phenomenological writing within archaeology has been the deconstruction of the dualistic thinking that is a product of post-Enlightenment rationalism. This has facilitated a radical reconceptualization of the nature of materiality and the relationship between people and artefacts. … Only by seeing objects as inanimate can we adhere to a model according to which humans impose meaning on a passive and pre-cultural universe. If, on the other hand, we recognize that artefacts, buildings, monuments and landscapes not only affect us but make us who we are, then our engagement with the archaeological record is necessarily a dialogue in which both archaeologists and the axes, houses or burials we study are created and transformed (Brück 2005: 65).

In order to explore these relationships between human movement and site, or place, an interdisciplinary consortium was brought together through funding from the UK Arts and Humanities Research Council (AHRC) to develop a Motion in Place Platform (MiPP). This consortium, led by the authors of this chapter, aimed to develop tools and working methods beyond the study of purely material cultures by adapting current motion capture technologies and enabling them to be taken out of the studio in an attempt to capture quantitative data, demonstrating links between environment and movement. Once they began capturing movement data, the MiPP team developed techniques for analysing the relationships between the data and the environments and conditions under which the data was captured. Earlier MiPP publications focus on construction of this system (see Dunn and Woolford 2012, Dunn et al. 2012). This chapter focuses on understanding how artefacts, sites, and places afford movement. It uses MiPP data in an attempt to demonstrate that these relationships do exist, can be quantified, and are crucial to our understanding of archaeological material evidence.

Framing Place

One of the most daunting challenges for the Motion in Place Platform has been the search for a clear, concise theoretical framework for understanding relationships between moving bodies and locations. This brings the project into the realm of ‘place’. It is beyond the scope of this chapter to fully cover the concept of a place. Even Tim Cresswell’s overview, *Place: A Short Introduction* is 168 pages long. We will however attempt to provide a general introduction by citing a number of key statements by authors working in a range of sectors to clarify and focus this issue with respect to our own research. The disciplines of Geography and Architecture

deal at length with notions of 'space' and 'place', but have great difficulty in agreeing on definitions for them. One branch of Geography, Human Geography, specifically addresses 'issues of the world, its people, communities, and cultures with an emphasis on relations of and across space and place' (Johnston 2000: 353), but human geographers continue to find it difficult to succinctly and consensually define Place. Cresswell, one of the representatives of this new discipline, opens his introductory book on place by stating:

> the popularity of place … is also a problem as no-one quite knows what they are talking about when they are talking about place. Place is not a specialized piece of academic terminology. It is a word we use daily in the English-speaking world. It is a word wrapped in common sense. In one sense, this makes it easier to grasp as it is familiar. In another sense, however, this makes it more slippery as the subject of a book. As we already think we know what it means it is hard to get beyond that common-sense level to understand it in a more developed way (Cresswell 2004: 1).

Cresswell discusses several definitions for place including one by the political geographer John Agnew stating that places are located with fixed objective co-ordinates on the Earth's surface. The word 'place', according to Agnew, is often used to refer to location, i.e., 'where'. But Cresswell points out that places are not always stationary:

> a ship, for instance, may become a special kind of place for people who share it on a long voyage, even though its location is constantly changing. … Places then, are material things … As well as being located and having a material visual form, places must have some relationship to humans and the human capacity to produce and consume meaning (Cresswell 2004: 7).

This relationship between a located, material place and a space defined by human thought or action has frequently been examined by cultural theorists. Henri Lefebvre's book *The Production of Space* (1991) has made a major contribution in this field, as has Michel de Certeau with his book *The Practice of Everyday Life* (1984), where he states:

> a space exists when one takes into consideration vectors of direction, velocities, and time variables. Thus space is composed of intersections of mobile elements. It is in a sense actuated by the ensemble of movements deployed within it. Space occurs as the effect produced by the operations that orient it, situate it, temporalize it, and make it function. … In short, space is a practiced place. Thus the street geometrically defined by urban planning is transformed into a space by walkers (Certeau 1984, 117).

Both Certeau and Lefebvre define space in terms of actions and practices of society. They write of non-material spaces. Lefebvre writes at length on the space of speech whereas Certeau focuses on the space of stories. Much theory on space and place avoids the materiality of human beings, their bodies, and how these bodies must act or move in places or spaces. The human geographer Derek McCormack outlines some of these challenges understanding moving bodies:

> if it is difficult – and indeed dangerous – to define what bodies are, there are some things we know bodies can do, even if our understanding of precisely how they do these things remains partial and fragmentary. First, bodies move: they walk, crawl, gesture, run, stumble, reach, fall and embrace. However, bodies move in more ways than one: yes, they move physically, but they also move affectively, kinaesthetically, imaginatively, collectively, aesthetically, socially, culturally and politically. Then, and second, we know that by moving in these different ways, bodies can "produce" or generate spaces. That is, the quality of moving bodies contributes to the qualities of the spaces in which these bodies move. Put another way, spaces are – at least in part – as moving bodies do (McCormack 2008: 1823).

McCormack asks readers to think of a football pitch before and after a game takes place. The presence of the football players as they move around the pitch alters the pitch not only physically, but sonically, socially, affectively and imaginatively. The pitch is the same physical site both before and after the game, but visitors would experience very different places at different times. Similarly, the anthropologist Tim Ingold, an academic who deals at length with the movement of human beings, bodies, and spaces, believes lives are lived not inside places, but through them. He uses the term 'wayfaring' to describe this human experience of movement between places. More specifically, he states:

> human existence is not fundamentally place-*bound* … but place-*binding*. It unfolds not in places, but along paths. Proceeding along a path, every inhabitant lays a trail. Where inhabitants meet, trails are entwined, as the life of each becomes bound up with the other. Every entwining is a knot, and the more that lifelines are entwined, the greater the density of the knot … Places, in short, are delineated by movement, not by the outer limits to movement (Ingold 2011: 148–9).

A space, then, is a practiced place, and we live our lives not inside places, but through them. But what are the practices which transform places into spaces? At what point does a space become 'inhabited', and through what processes of human intervention in the material record do places become spatial artefacts? And, how do we move through these spaces? How can we define, capture and understand them? These were the starting questions for the development of the Motion in Place Platform. Additionally, MiPP aimed to address a further, equally

complex question, and to shed new light on the relationship between environment, accumulated experience and perception.

When reflecting upon a sign at a railroad crossing stating: 'Stop, Look and Listen', Ingold states:

> supposing that our knowledge is ultimately founded on sensory experience, how do we know that the sights and sounds that come to our notice are all manifestations of the same thing … If we hear sounds rather than things (like trains), then how do know that *this* sound I hear belongs to *that* train I see? … [How we pose these questions] bears the imprint of a certain way of imagining the human subject – namely, as a seat of awareness, bounded by the skin, and set against the world – that is deeply sedimented in the Western tradition of thought. The problem of perception, thus, is one of how anything can be translated or "cross over" from the outside to the inside, from the macrocosm of the world to the microcosm of the mind … As such, perception is not an "inside-the head" operation, performed upon the raw material of sensation, but takes place in circuits that cross-cut the boundaries between brain, body and world (Ingold 2000: 243–4).

The Architecture theorist Juhani Pallasmaa clarifies this relationship between interior and exterior environments as follows:

> our bodies and movements are in constant interaction with the environment; the world and the self inform and redefine each other constantly. The percept of the body and the image of the world turn into one single continuous existential experience; there is no body separate from its domicile in space, and there is no space unrelated to the unconscious image of the perceiving self (Pallasmaa 2009: 40–1).

All these questions and debates pertaining to motion, place, and perception remain just as subjective as they have been for hundreds of years. The Motion in Place Platform built on advances in motion capture technologies in order to provide qualitative data to reinforce or challenge these debates. It specifically explored technologies and methods for observing and analysing the practices and movements involved in the making of place and/or space.

Human factors and techniques of the body

Experimental archaeology is a branch of archaeology that replicates or attempts to replicate past processes in order to understand what is found in archaeological records. This branch is often cited as offering an important asset in the study of human interaction with material culture, especially when dealing with remote periods of history where there are few other sources of data on the human

interventions. This attempt to understand processes has found many expressions in the discourse of archaeological theory, including the so-called *chaîne opératoire*, or 'operational sequence' theory (see for example Bar-Yosef and Van Peer 2009). However, due to an understandable desire to adhere to empirical evidence, means of inferring the human movement behind interventions are rarely considered in the reconstruction of archaeological environments. The most obvious reason being that buildings, features and artefacts can be understood and reconstructed (whether digitally or not) from empirical archaeological remains, whereas there is little or no direct evidence for how people might have looked and moved through the places they created. Approaches that seek to go beyond this are methodologically fraught as a result of 'the human factor'. It is further inevitable that such living interpretation will be problematic, since environments, objects and landscapes are, to one extent or another, cultural constructs: society attaches significance to landmarks and features which cannot be retrieved without written records. However, implicit in all archaeological interpretation is the truth that this human factor is behind the process of the material record's creation. Human processes have, in the past, been regarded as intangible and unrecoverable and therefore implicitly and explicitly written off in experimental archaeology; and the problems of equating present-day movement with its historical counterparts has been discussed elsewhere (Brück 2005). This is reflected in global regulatory practices on 'intangible cultural heritage', which UNESCO considers protectable alongside tangible heritage (such as the Great Wall of China) and natural heritage (such as the Amazon basin). Intangible cultural heritage encompasses language, oral traditions, practices transmitted by gesture, music and so on. Recent governance models seek to sustain traditions, which are extant by supporting those who practice and transmit them: 'not only the masterpieces but also the masters' (Kirshenblatt-Gimblett 2003). When one is dealing with pre-literate societies, such as the British Iron Age, there are of course no individual 'masters' to whom cultural practices can be traced. There is therefore a tension in the reconstruction, as opposed to the preservation, of ancient intangible heritage. These traditions are 'dead', and therefore not 'preservable'. For this reason, experimental archaeologists have traditionally shunned 'the human factor', focusing instead on the re-creation of archaeological features from empirical evidence (Harding 2009, Coles 1979). Indeed, the very notion of attempting to include 'the human factor' in experimental reconstructions is viewed with scepticism at best and outright hostility at worst. As Peter Reynolds, the founding director of the Butser Ancient Farm experimental archaeology laboratory in Hampshire, England (see www.butserancientfarm.co.uk) states:

> in real terms it is only sensible to examine structures physically and as far as possible to dehumanise the examination process. Re-enactment is best left as a dramatic indulgence to the imagination, which can be recognised as singularly valueless and instantly forgettable. … History, and by implication

> prehistory, is swiftly becoming a tabloid newspaper sub-editor's view of the past (Reynolds 1993).

While some might view this undermining of imagination as being somewhat harsh, it nonetheless highlights a significant gap not only in 'real world' reconstruction projects such as Butser, but also, in the application of virtual reality reconstruction, or any attempt to (re)create past movements in any place.

In British Iron Age domestic culture, there are no historic or material referents to how particular houses were built, or how artefacts such as arrowheads or ceramics were made. The methods must be inferred by a process of logical deduction, and examination of the available empirical evidence. However, how we approach this process of deduction can, and often does, involve a human factor. The reconstruction process in experimental archaeology now has a long tradition of researching and utilizing past methods of construction and craft to construct (the term 'reconstruct' is explicitly avoided in the literature – see Reynolds 1993) non-extant buildings using those methods. The experimental approach, now well established and widely referred to, requires the 'human factor', in that it requires human intervention in, and interaction with, the physical world. While it is not possible to go back in time to capture the exact motions involved in creating archaeologically relevant places, we can capture current activities and the physical processes and their transmission in order to gain more insight into probable past activities. These processes the MiPP team hoped to capture in order to better understand possible activities in Iron Age Roundhouses, are what the French sociologist Marcel Mauss refers to as techniques of the body, transmitted through tradition:

> I call technique an action which is effective and traditional … There is no technique and no transmission in the absence of tradition. This above all is what distinguishes man from the animals: the transmission of his techniques … we are dealing with techniques of the body. The body is man's first and most natural instrument. Or more accurately, not to speak of instruments, man's first and most natural technical object, and at the same time technical means, is his body (Mauss 1973: 73).

Mauss used his concept of techniques of the body to analyse numerous motions and activities, for example:

> during the War I was able to make many observations on this specificity of techniques, e.g. the technique of digging. The English troops I was with did not know how to use French spades, which forced us to change 8,000 spades a division when we relieved a French division, and *vice versa*. This plainly shows that a manual knack can only be learnt slowly. Every technique properly so-called has its own form (Mauss 1973: 71).

Mauss' techniques of the body became clear during a studio-based capture at the University of Bedfordshire for the MiPP project. When asked to sweep out the virtual round house, one of the performers emulating Iron Age activities grabbed a twentieth century push-broom in the corner of the studio and began sweeping with it. It was obvious to people watching that this was a twentieth or even twenty-first century movement. This action was a form closely linked to a 'modern' artefact. After the performer was reminded that the push broom was a twentieth century invention which would not have existed in a round house, she swung the broom from side-to-side without touching the floor. Neither of these sweeping actions could be considered 'correct' and neither helped us understand how or why round houses were constructed in forms we have found. The studio-based approach to modelling movement demonstrated the power of techniques, the importance of provenance and the need to document assumptions made during capture.

Figure 6.1 Sweeping in a) virtual (U. Sussex) and b) physical (Butser Ancient Farm) round house

Capture in material and immaterial environments

The experience with the broom showed that the connection to material objects such as tools and buildings are of crucial importance in elucidating our understanding of possible behaviours and movements at an historically inaccessible period. Consequently, a further set of experiments was devised around the tasks of

sweeping within two (re)constructions of the same round house. Both round houses were constructed according to excavation data from Moel y Gerddi, Wales (Kelly 1988). The first, immaterial, or virtual round house was created using projections and a head-mounted display at the University of Sussex. The second, material, or physical round house was constructed of materials expected to have been available in Iron Age Wales at the Butser Ancient Farm. Two performers were given a broom, constructed using materials and methods sufficiently generic as to approximate to those likely to have been used in the Iron Age, to sweep the virtual round house as well as the physical round house (see Figure 6.1). In the virtual round house, their movements had no consequence. In the physical round house, phenomenologies taught them that large, fast movements not only failed to clear the floor, but also created dense clouds of dust and damaged the floor of the house. The performers' movements were then compared with the movements of an experimental archaeologist who worked in the house on a daily basis, performing the same task. Other daily activities including grinding grain with a quern, fetching water, and making bread, were all captured both with props in the studio, and with (re)constructed artefacts in the round house. We may thus learn from this that even well-rehearsed models of phenomenological and experimental archaeology are dependent on cultural conditioning and personal experience, and highlight Brück's point (2005) that the reception of locations is not constant or ahistorical. The use of motion capture technologies allowed the research team not only to capture motion data for visualization, but to analyse the difference in movement dependent upon the artefact, environment and the experience of the user. Figure 6.2 shows respectively an inexperienced user and the experimental archaeologist operating a quern stone for grinding corn. It is plain to see that there is a far clearer and more consistent set of motions, along with clear clues as to the object's most efficient usage: the employment of a circular motion on the quern stone by a skilled operator, rather than the back-and-forth motion of the inexperienced user. This is, in effect, an extension of experimental archaeology, which allows us to infer how people are likely to have interacted with their physical environments and how those environments (or tools) were constructed.

As noted, the purpose of this exercise is, emphatically, not to attempt to re-enact possible scenarios of history or prehistory, but to capture and visualize human interaction with place and material culture as documented by archaeological evidence. During the capture process, the MiPP team became aware that numerous assumptions being made about motion needed to be recorded in order to provide a context for the data (commonly referred to as 'metadata'). For example, when capturing in the studio, the hard floor and performer's shoes constrained and reshaped the movement, so this capture was replicated barefoot, outdoors on uneven grass. External factors such as footwear, clothing, training, experience, age and gender of the mover impacted the motion data. Many assumptions of this kind are either overlooked altogether, or implicitly encoded into models, of which the virtual round house offers a clear example. While such assumptions cannot be removed from the reception and transmission of virtual environments, MiPP

was able to propose a means for isolating and critically assessing them, as readily shareable visual material that avoids the pitfalls of discipline-specialist language and jargon.

It is clear that one key factor missing from these reconstructions of hypothetical tasks is the ability to annotate and describe the motion data. The main difference between the kind of 'human factor' representations and re-enactments that are currently viewed with suspicion by experimental archaeologists is that digital capture should allow particular actions, and particular temporal points in each trace, to be labelled with a) what material evidence relates to each action or trace or b), if there is no material evidence, what action has been represented. Given the history of a field such as archaeology, where there are already highly developed information recording and presentation conventions, marking up quantitative representations of immaterial events should be straight-forward. One way of doing so might be to assign levels of certainty to various activities; in much the same way that textual mark-up allows editors to grade the scribal or editorial certainty of sections of text. It should be possible, for example, to state that 'we have 100 per cent certainty that there were activities to do with fire in this room because there is a hearth and charring, but only 50 per cent certainty that the fire was used for ritual activity because of the paucity of supporting evidence'. It should also be possible to develop a system for citing archaeological contexts in support of particular types of activity.

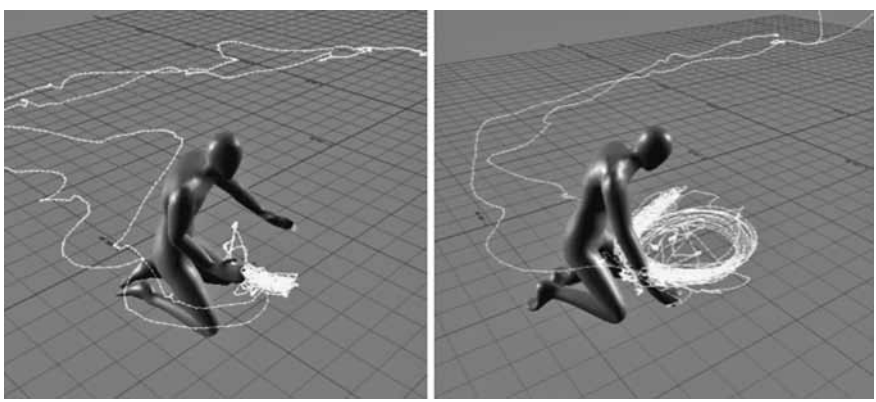

Figure 6.2 a) Inexperienced performer using quern to grind grain by using short, rocking movements. b) Experienced experimental archaeologist grinding grain with larger movements and rotating quern through its entire range of movement

Affordances and effectivities

James Gibson wanted to understand how perception – that is, an animal's only means of collecting information from outside itself – can inform the animal about the meanings of environmental objects. For example, how does perception inform my cat that she can or cannot jump onto the kitchen table, or how does perception inform my daughter that she can or cannot reach something?

Theories that address such questions fall into two categories. The first category known as indirect-perception assumes that objects and events have no inherent meaning, and thus the meaning must be created internally and stored by the animal. The second category, direct-perception assumes that objects and events have inherent meaning, which is detected and exploited by the animal without mental calculation. J.J. Gibson's theories fell into the direct-perception category. In fact, within experimental psychology, it is not clear that the direct-perception category even existed before Gibson (Jones 2003: 107).

The theory of affordances is based on ecological psychology, and advocates that knowing is a direct process. It states that an animal's (e.g. human's) perceptual system extracts invariants, or unchanging relationships embodying the ecologically significant properties of the perceiver's world. Gibson bases his theory on the tenet that animal and environment form an inseparable pair. We can extend this slightly to say that humans and their environment, whether contemporary or past, form an inseparable pair.

Gibson uses ecological physics to clarify this complementarity. Such physics considers functions of the environment at an ecological level instead of the levels of space, time, matter, etc., within classical physics. Affordances have to be described relative to the animal, i.e. the person perceiving them. For example, a chair's affordance 'to sit' results from a bundle of attributes, such as 'flat and hard surface' and 'height', many of which are relative to the size of an individual. Later work with affordances builds on this so-called agent-environment mutuality. Affordances can be considered as measurable aspects of the environment, but only to be measured in relation to individuals in said environment. For example, a 'climbability' affordance of stairs is specified as a ratio of riser height to leg length. People of different heights may, or may not, perceive stairs as climbable depending on their own leg length, as opposed to some extrinsically quantified value.

Just as 'place' is a very complex issue with numerous interpretations and understandings, 'affordance' is a dense issues whose depths we can only begin to explore here. Keith Jones gives a clear overview and history of the concept in the journal *Ecological Psychology* (2003), and Mark Gillings uses affordances to understand ancient landscapes while warning that:

> affordance is not a static concept and that considerable debate has, and continues to take place, within the field of Psychology, in large part a consequence of Gibson's own thoughts on the topic being a work-in-progress. The assumptions that underlie direct perception in turn require a new ontology capable of dealing

> with the requirement that the environment now embodies meaning alongside its raw physicality. This is where the notion of affordance enters the picture. The first point to realise is that having introduced the concept of affordance, Gibson's own attempts to define it in detail were at best vague. This, in turn, has led to considerable efforts within the field of Ecological Psychology (as well as Psychology more broadly) to develop a rounded and coherent theory of affordances. … Whilst all take Gibson's assertion that affordances are environmental properties that are meaningful to animals as their point of departure, they differ in a number of ways, most importantly for us what qualities shared between animals and environments constitute affordances and whether they can be considered to exist in the absence of animals (Gillings 2012: 605).

Gillings also points to an essay by Anthony Chemero characterizing two dominant approaches within the psychological literature to this problem of defining an effective theory of affordance. In the paper Chemero defines these approaches as selectionist and dispositional. Through the selectionist model, affordances are portrayed as resources in the environment, which are exploitable by animals. These affordances exist in the landscape prior to arrival of the animal and therefore do not depend upon the presence of an animal in order to exist. The concept of 'selection' derives from the direct association between availability of affordances and evolutionary selection pressure. In direct contrast, the dispositional view proposes that affordances are properties of the environment, which only manifest in certain circumstances and cannot always be considered as present. The dispositional view states that under different circumstances, the same environment may reveal different properties (i.e. affordances) in the presence of different animals (Chemero 2003: 182–3).

To overcome this contradiction between the selectionist and dispositional definitions, Chemero offers an alternative – a relational theory of affordances. This approach differs in its insistence that affordances not be considered as properties (whether latent or dispositional) of either animals or environments in any formal sense, but instead relations between the two. Through this relational theory, the perception of affordances is contingent upon what he terms 'feature placing', i.e., the ability to perceive that a situation has a certain kind of feature (e.g. flooding) and that this in turn requires certain kinds of action that draw upon the abilities of the perceiving animal. To Chemero, affordances can never be properties of environments, but instead are linked to 'features of whole situations'. Humans form an essential part of these situations with affordances lying in the relationships between the abilities of humans and situational features. Put simply, in perceiving affordances, humans perceive relations. Changes in affordance can come from both changing environmental situations and animal abilities (Chemero 2003: 185–92); the latter changes come through social factors such as experience and learning as evidenced by Mauss.

Naoya Hirose further explains the relational aspects of affordances by introducing 'Effectivities' (Hirose 2002). Effectivities, he explains, are means

for acting that a person can use to realize a specific affordance. Affordances and effectivities are complementary concepts. Effectivities may change as the state of a person changes, because they are properties linked to the individual person. Tool use is a typical case where effectivities some into play. Tools may extend humans' existing action and perception capabilities. Tools are treated as functional extensions of the user; they 'play a central role in extending the user's effectivities to realize affordances of the environment. Consequently, tool use involves the task to detect affordances not of the tool itself, but of functional relations between the tool and the environment' (Hirose 2002: 291). Hirose goes on to explain:

> a blind person's stick cannot be sensed for itself, as a person gets accustomed to using it. The stick can be embodied as part of the user's arm. For that reason, it is worthwhile … to investigate the perception by probing with hand-held objects. Recently, perception of hand-held objects has been studied in the area of dynamic touch. … Dynamic touch is the kind of touch that occurs when one grasps an object firmly and wields it. Investigations on dynamic touch have shown that one can perceive various properties of a hand-held object by wielding and hefting it without help of vision. Moreover, one can perceive not only properties of a hand-held object itself, but also properties of a distal object by probing with a hand-held object (Hirose 2002: 290–3).

In other words, tools become invisible to the user's perception. They also alter a user's effectivities of perceiving and acting. Tool use effects both perception and action. Tools extend a user's body into the environment, and become a direct link connecting body and environment, making it very difficult to demarcate boundaries between people and places.

Conclusions

Both the discussions of 'place' and 'affordance' demonstrate that humans and their environments, whether contemporary or past, form an inseparable pair. The boundaries between bodies, tools, and environment are fluid and dependent upon relationships more than materials. Ecological approaches to embodiment maintain that tool use extends users' bodies beyond the surface of the skin. Through dynamic touch and probing, the user's perceptual body can be extended into the surrounding environment. This brings us back to our MiPP experiment with sweeping. When the performers were sweeping in a 'sterile' studio, some information was being fed into the performer's body through the tool, i.e. the broom, but very little information was afforded by the smooth surface of the studio floor. However, when the performer took the same broom to the reconstructed roundhouse at Butser, a wealth of environmental information was obtained through the relationship of the broom head and the hard dirt floor. In order to continue to sweep, he had to change his movement in accordance. He had to make shorter strokes to prevent brushing

up a large cloud of dust. He had to avoid wooden posts and monitor the placement of his feet on the irregularly shaped floor. All these environmental elements became embedded in the motion data. If this motion is re-played in a sterile, virtual environment, the extra data becomes exceptionally apparent as the virtual character moves in and out of the 'flat' virtual floor. Likewise, if the movement data is captured on a smooth floor in a studio, and placed onto an uneven floor in a reconstruction, the virtual character floats above it or steps through it. Modern animation packages and game engines have systems to lock character's feet to surface topologies in order to deal with these issues with varying degrees of accuracy. However, issues of foot locking are most often seen as problems rather than invitations to accept that human beings exist in a material world. When they are added to virtual reconstructions, the relationships between their bodies and the virtual materials of the reconstructed objects needs to be taken into account. When material aspects of the virtual characters are not taken into account, the characters act as spirits floating through dead worlds without influencing or being influenced. Only by accepting that the materiality of the characters moving through these reconstructions needs to be afforded as much attention as the materials used to construct the buildings and landscapes can we hope to have realistic depictions of human activity, and mobility in these reconstructions.

To paraphrase Spinoza, there is much we still do not know about relationships between humans and their environments. Humans remain elusive and paradoxical, always excessive of attempts to define their essence. However, by using tools and concepts such as affordances, effectivities and place, we can begin to understand how past places may have been used in order to better understand what has been left behind. No, it's not possible to definitively know how Iron Age Britons used their round houses. We can infer past movements from an understanding and analysis of current movement in much the same way we infer the structure of past buildings and material objects through fragments that have survived to our current time. However, just as we make clear distinctions between what material objects have actually been uncovered and what we conjecture to have existed, we need to be clear about exactly what movements we are using as context and under what circumstances this movement has been captured.

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For more information, please see http://www.motioninplace.org.

References

Bar-Yosef, O., and Van Peer, P. 2009. The *chaîne opératoire* approach in Middle Paleolithic archaeology. *Current Anthropology*, 50(1), 103–31.

Brück, J. 2005. Experiencing the past? The development of a phenomenological archaeology in British prehistory. *Archaeological Dialogues*, 12(1), 45–72.

Certeau, M. de 1984. *The Practice of Everyday Life*. Trans S.F. Rendall. Berkeley, CA: University of California Press.

Chemero, A. 2003. An outline of a theory of affordances. *Ecological Psychology*, 15(2), 181–95.

Coles, J.M. 1979. *Experimental Archaeology*. London: Academic Press Inc.

Copeland, T. 2009. *Akeman Street: Moving through the Iron Age and Roman Landscapes*. Stroud: The History Press.

Cresswell, T. 2004. *Place: A Short Introduction*. Walden, MA: Blackwell.

Dunn, S. and Woolford, K. 2012. Reconfiguring experimental archaeology using 3D reconstruction. *EVA London 2012 Electronic Visualisation and the Arts, Computer Arts Society, British Computer Society*, 172–8.

Dunn, S., Woolford, K., Norman, S.-J., White, M. and Barker, L. 2012. Motion in place: A case study of archaeological reconstruction using motion capture, in *Revive the Past: Proceedings of the 39th Conference in Computer Applications and Quantitative Methods in Archaeology*, edited by Philip Verhagen. Amsterdam: Amsterdam University Press, 98–106.

Gibson, J.J. 1979. *The Ecological Approach to Visual Perception*. Boston: Houghton Mifflin Company, 332.

Gillings, M. 2012. Landscape phenomenology, GIS and the role of affordance. *Journal of Archaeological Method Theory*, 19, 601–11.

Harding, D.W. 2009. *The Iron Age round-house: Later prehistoric building in Britain and beyond*. Oxford: Oxford University Press.

Hirose, N. 2002. An ecological approach to embodiment and cognition. *Cognitive Systems Research* 3, 289–99.

Ingold, T. 2000. *The Perception of the Environment. Essays in Livelihood, Dwelling and Skill*. Abingdon: Routledge.

Ingold, T. 2011. *Being Alive. Essays on Movement, Knowledge and Description*. Abingdon: Routledge.

Jones, K.S. 2003. What is an affordance? *Ecological Psychology*, 15(2), 107–14.

Johnston, R 2000. Human Geography, in *The Dictionary of Human Geography*, edited by D. Gregory, R. Johnston, G. Pratt, M. Watts, S. Whatmore. Oxford: Blackwell, 353–60.

Kelly, R.S. 1988. Two late prehistoric circular enclosures near Harlech, Gwynedd. *Proceedings of the Prehistoric Society*, 54, 101–53.

Kirshenblatt-Gimblett, B. 2004. Intangible heritage as a metacultural production. *Museum International*, 56(1–2), 52–65.

Lefebvre, H. 1991. *The Production of Space*. Trans D. Nicholson-Smith. Oxford: Blackwell.

McCormack, D.P. 2008. Geographies for moving bodies. *Geography Compass*, 2/6, 1822–36.

Mauss, M. 1973. Techniques of the body. *Economy and Society*, 2(1), 70–88.

Norman, D. 1988. *The Design of Everyday Things*. New York: Doubleday.

Pallasmaa, J. 2009. *The Eyes of the Skin*. Chichester: John Wiley and Sons.

Reynolds, P. 1993. Experimental reconstruction. The report of a specific construction based upon the excavation of a great round house at Pimperne Down in Dorset, including an account of the life of the structure and its final dismantlement. In *An Iron Age Settlement in Dorset: Excavation and Reconstruction*, edited by D.W. Harding, I.M. Blake and P.J. Reynolds. Edinburgh: Edinburgh University Press (Monograph 1).

Roach, J. 1996. *Cities of the Dead: Circum-Atlantic Performance*. New York: Columbia University Press.

Tilley, C. 1994. *A Phenomenology of Landscape: Places, Paths, and Monuments*. Oxford: Berg.

Chapter 7
Mobility and the Skeleton: A Biomechanical View

Thomas G. Davies, Emma Pomeroy, Colin N. Shaw, Jay T. Stock

Introduction

Research over the past 100 years has shown the extent to which the skeleton is far from a fixed, genetically determined structure. Humans in particular display a high degree of physiological and developmental flexibility (plasticity) that has facilitated the colonization of environments across the globe (Wells and Stock 2007). Skeletal adaptation during growth is critical to the development of the skeleton for adult life; the skeleton is a plastic, mouldable tool. It is susceptible to disease, degeneration, and responds to strains arising from behaviours. It is this responsiveness, or adaptation, to functional loading that arises from habitual behaviour that provides a means with which to gain insight into activities and lifeways of individuals in the past. Many of the most significant and repetitive strains to act upon the skeleton arise from mobility.

Mobility, the movement of individuals across a landscape, influences the size and shape of their bones. The skeleton responds to the loading that results from walking or running (or paddling in aquatic settings) in various ways. These include: by reinforcing the shafts of the limb bones to resist the strains imposed on them (Ruff et al. 1993); through reinforcement of muscle attachment sites (markers of occupational stress or musculo-skeletal stress markers) (Hawkey and Merbs 1995); and on the curvature of bones (De Groote 2011). Through examining these indicators of response to skeletal loading, it is possible to gain insight into temporal and spatial patterns of mobility through these functional stresses generated by different lifestyles. Different subsistence modes, activity levels, and patterns in gendered division of labour lead to variation in the mobility of past populations, which may be reflected in skeletal morphology (Larsen 1999).

This chapter reviews the variety of insights into mobility that are offered by skeletal cross-sectional geometric studies that measure the quantity and distribution of bone in long bone shafts. These insights demonstrate the utility of biomechanical approaches to archaeological questions concerning mobility, and highlight the extent to which mobility is an embodied action, reflecting the extent of interaction between individuals and their environments. We begin by offering a brief introduction to the theory and methods behind cross-sectional geometric analysis of bones, and proceed to discuss some of the theoretical debates within

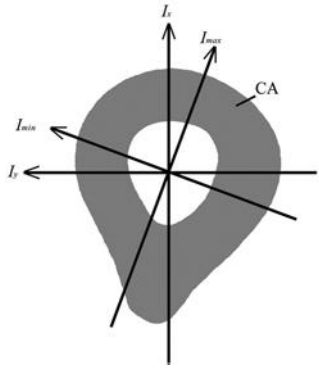
this sub-field concerning the interpretation of past activity on the basis of this technique (see also Pearson and Lieberman 2004, Ruff et al. 2006a, Ruff 2008 for further discussion). In the last section, we present case studies to demonstrate the potential of the method for a range of questions regarding mobility in archaeological populations.

Development of a biomechanical approach to mobility

Over the past forty years research has shown that the behaviour of an individual during life has a considerable and measurable impact upon their skeleton (Ruff 2000, Ruff et al. 1993, 1994, Shaw and Stock 2009 a, b, Stock 2006, Stock and Pfeiffer 2001, 2004, Trinkaus et al. 1994). This relationship is of interest to human palaeontologists and bioarchaeologists alike, since it offers a potential means of interpreting past human behaviour (Ruff 2000). Whilst the exact physiological mechanisms linking mobility and skeletal morphology have proven hard to define (Gosman et al. 2011), it is clear that, during life, bone material is added to the shafts of limb bones in response to elevated loading and activity in order to ensure it can withstand the loads it experiences (e.g. Jones et al. 1977, Lieberman et al. 2001, 2003, Shaw and Stock 2009 a, b). Conversely, decreased activity (loading) will result in bone loss (and more gracile skeletal elements). Mobility is one of the most significant factors influencing the degree and extent of biomechanical loading experienced and thus quantification of the external morphology and internal architecture of a bone can reveal signatures of mobility. This understanding can be applied to test archaeological predictions about habitual behaviour among past populations (Bridges 1989, Marchi 2008, Ruff et al. 1984, Sladek et al. 2006a, Sparacello and Marchi 2008).

By modelling long bones as beams and applying theory from mechanical engineering, we can estimate their mechanical properties by measuring the amount and distribution of bone material in the cross-section (Figure 7.1) (Ruff et al. 1993). The cross-sectional areas of bone are proportional to axial rigidity or resistance to compressive forces; or in other words, the greater the load a bone experiences in life, the greater the cross-sectional area. Further measures of mechanical properties include second moments of area (also known as area moments of inertia, and denoted by the letter *I*), which correspond to bending rigidity. As well as responding to overall compressive loading, bone is preferentially deposited in the shaft in a way that reflects the direction of the greatest load it experiences. So, for example, individuals who walk or run more subject their lower limb bones (the femur and tibia) to greater anteroposterior (front-to-back) bending strains, and thus the cross-sectional shape becomes more anteroposteriorly elongated (or elliptical). Second moments of area are calculated about an axis through the section in order to measure bending rigidity perpendicular to that axis. Commonly used axes include the maximum and minimum (I_{max} and I_{min} respectively), or anteroposterior and mediolateral (I_x and I_y). The ratio of two second moments of

area measured perpendicular to one another (I_x/I_y or I_{max}/I_{min}) provides a simple quantification of cross-sectional shape, or the distribution of bone within a section, and its circularity (see Figure 7.1). The polar second moment of area (the sum of any two perpendicular second moments of area, denoted by *J*) is proportional to torsional rigidity (Ruff et al. 1993), reflecting overall levels of loading.



Symbol	Definition	Mechanical relevance
TA	Total subperiosteal area	External quantification of combined cortical bone and medullary area
CA	Cortical area	Correlate of compressive strength
I_{max}	Maximum second moment of area	Correlate of maximum bending strength
I_{min}	Minimum second moment of area	Correlate of minimum bending strength
I_x	Second moment of area, x axis	Correlate of bending strength about x axis
I_y	Second moment of area, y axis	Correlate of bending strength about y axis
J	Polar second moment of area	Sum of any perpendicular second moments of area, correlate of torsional strength
I_{max}/I_{min}	Cross-sectional shape, max-min	Estimate of distribution of cortical bone in relation to the principal axes
I_x/I_y	Cross-sectional shape, x-y axes	Estimate of distribution of cortical bone in relation to the principal axes

Figure 7.1 Biomechanical properties for bone cross-sections

A biomechanical approach to the study of human long bones can be traced back to theoretical work by Wolff (1892), and Koch's (1917) geometric description and estimation of stresses (Rybicki et al. 1972). Whilst there have been debates as to specific features related to bone functional adaptation, the concept that bone adapts to its mechanical environment during life creating measurable differences in morphology that reflect past mechanical environments is widely accepted by paleoanthropologists and bioarchaeologists (Ruff et al. 2006a).

Measurements of the biomechanical properties of limb bones are typically made at the midpoint of the shaft, although in the humerus measurements are often taken at 35 per cent of bone length (from the distal (elbow) end) in order to avoid the undue influence of major muscle attachments. While early studies relied on natural breaks in bones or physically cutting them in order to obtain an image of the cross-section, a wealth of non-destructive methods are now available, including external moulding (Stock and Shaw 2007), radiography (Trinkaus and Ruff 1989), and either CT scanning (Sumner et al. 1985) or 3D laser scanning (Davies et al. 2012). These developments have greatly widened the scope for applying such techniques to skeletons of past populations.

The theoretical principle that bone cross-sectional properties reflect loading and activity during life have been repeatedly demonstrated by *in vivo* studies of humans and animal models. Jones et al.'s (1977) classic study demonstrated pronounced hypertrophy (increased deposition) of bone on the playing side in tennis players, with cortical thicknesses 34 per cent greater compared to the non-

playing side (Figure 7.2). Subsequent studies of physiological plasticity in the skeleton of living humans further confirm the flexibility of skeletal tissue to respond to loadings experienced during life (Nikander et al. 2006, Shaw and Stock 2009a, b). Studies of tennis players have shown significantly greater asymmetry for second moments of area (I_{max}, I_{min}) of the midshaft and distal humerus compared to controls (Haapasalo et al. 2000) and greater humeral torsional rigidity (J) and increased bone area in the loaded upper limb (Bass *et al*. 2002). Across a variety of sports (Nikander et al. 2006), pronounced differences were found in bone rigidity in the upper or lower limbs that were primarily loaded during the athlete's main sporting activities, when compared to non-athletic controls (reported Shaw and Stock 2009a). Upper limb robusticity in modern human swimmers and cricketers, confirms that variation in cross-sectional properties may reflect a phenotypically plastic response to habitual loading patterns (Shaw and Stock 2009a), whilst investigation of the tibial diaphysis (Shaw and Stock 2009b) in cross-country runners, hockey players, and controls, suggested morphological traits can reflect adaptation to their differing habitual locomotor activities.

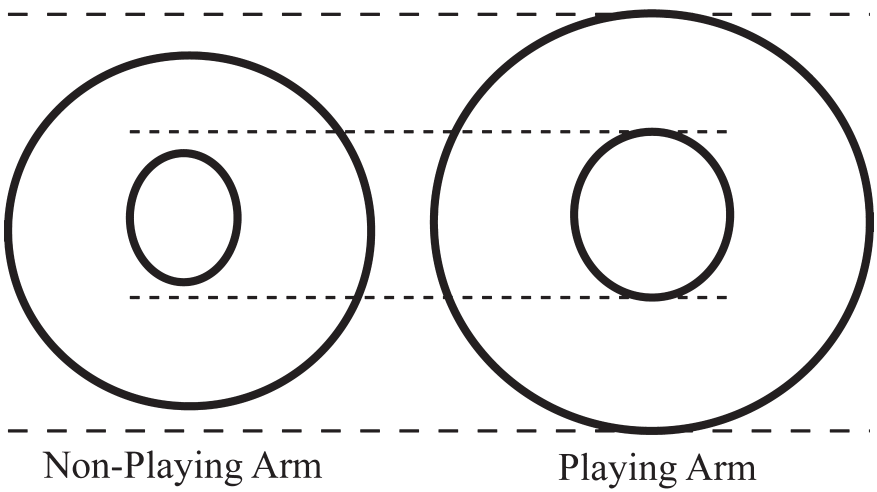


Figure 7.2 Cross-sectional hypertrophy (increased diameter and thickness) in the humerus of the playing arm of professional tennis players
Source: Based on Jones et al. 1977: figure 4.

Experimental studies have demonstrated close correspondence between experimental strain gauge results (that is, direct measurements of strain experienced by the bone) and theoretical predictions for cortical bone (Huiskes 1982). Studies of mechanical adaptability of bone have evaluated the theory through experiments involving sheep (Lanyon and Baggott 1976, Lanyon and Bourn 1979), rats

(Steinberg and Trueta 1981) and chicks (Biewener and Bertram 1994). Rubin and Lanyon (1984) have demonstrated that bone mass is maintained only under functional loading, otherwise disuse leads to bone resorption (loss), particularly endosteally (i.e. on the inner bone surface). They later observed that each region of bone may be programmed to accept a particular level of strain from which any deviation will stimulate a remodelling response to either increase or decrease bone mass (Rubin and Lanyon 1987). Studies across a range of species and activities have observed that morphology is adapted to produce an economical and optimized structure and behavioural modifications result in similar peak strain magnitudes across a range of species (Rubin 1984).

Endo and Kimura (1970) first applied a biomechanical approach to a Pleistocene human on the break of the Amud 1 Neanderthal tibia. Lovejoy et al. (1976) demonstrated the utility of a biomechanical approach to long bone structural analysis by showing how engineering concepts could be applied to human archaeological samples (Ruff 2000) and emphasize the importance of characterizing the spatial distribution of bone tissue in the cross-section of the long bones. Early archaeological applications of the approach explored differences between Neanderthal bones (Lovejoy and Trinkaus 1980). A comparison of just three Neanderthal bones relative to modern human samples revealed twice the relative bending and torsional strengths observed among recent anatomically modern humans, suggesting particularly high activity levels (mobility) amongst Neanderthals (Lovejoy and Trinkaus 1980).

Early studies of anatomically modern human skeletal remains applied biomechanical principles to the study of the agricultural transition in the New World. Larsen (1981) discussed skeletal size reduction (including diaphyseal diameters) with the transition to agriculture on the Georgia coast. This study was expanded to incorporate a cross-sectional geometric approach by Ruff et al. (1984). They observed a significant reduction in all cross-sectional geometric properties from pre-agricultural to agricultural samples, and increased circularity in cross-sectional shape of the femur among the agriculturalists (Figure 7.3). The variation was interpreted as suggesting reduction in activity levels, including lower mobility, or change in types of activities loading the lower limb (Ruff et al. 1984), as populations adopted a more sedentary agricultural lifestyle. Indeed, it has been argued that femoral midshaft cross-sectional shape can be viewed as providing a 'mobility index' or a measure of the extent of terrestrial mobility of a population.

The differences observed on the Georgia Coast are not necessarily characteristic of all pre-agricultural and agricultural groups. An increase in estimated rigidity of bones has been associated with the agricultural transition in the southeastern United States, in which maize agriculture is viewed as more physically demanding than hunting and gathering and is reflected in changes in skeletal diaphysis dimensions (Bridges 1989, Bridges et al. 2000). These examples highlight the importance of understanding the diverse nature of subsistence economy and its interaction with activity and particularly mobility patterns.

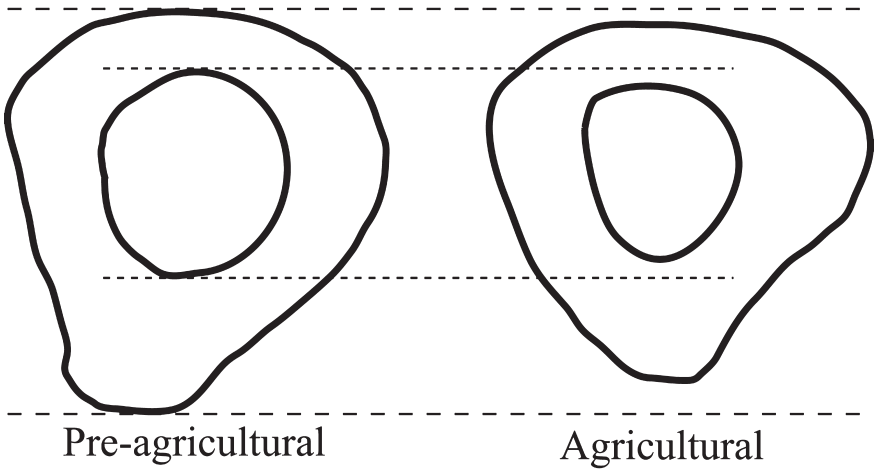


Figure 7.3 Changes documented in the femoral cross-sectional morphology with transition to agriculture. Example cross-section outlines for representative pre-agricultural and agricultural individuals at the femur midshaft

Source: Redrawn from Ruff et al. 1984: figure 3.

Theoretical debates

What follows is a brief discussion of some of the debates that are most relevant to the issues surrounding the use of biomechanics to infer mobility in past populations. Readers are referred to Pearson and Lieberman (2004) and Ruff et al. (2006a) for further discussion of these and other debates.

(a) What is the influence of body size upon the limb?

Bone responds to functional loading, creating signatures that are of interest to those studying mobility (Ruff et al. 1993). However, in order to gain insights that are relevant to behavioural activities, one must first account for the influences of body size upon the limb since larger, heavier individuals will clearly create greater loads on their bones than lighter individuals undertaking the same level of activity (Ruff 1984, 2000, Ruff et al. 1993). Once the effects of body size are removed, differences in mean cross-sectional properties between populations can then be attributed to population differences in activity that have generated different functional loading regimes upon the limbs (Ruff 1984).

Whilst recommended practices for standardizing cross-sectional properties have changed over time, Ruff (2000) has demonstrated that in humans long bone rigidity scales most closely to body mass, because mass is a major source of loading across the skeleton, especially for the lower limb. Body mass estimates derived from

other skeletal measurements such as femoral head diameter or the combination of body breadth and stature (Ruff et al. 1997) must be used to standardize bone cross-sectional areas. The morphology of the upper limb correlates similarly with body mass, despite not being weight bearing (Ruff 2000). It is unclear why this should be so, although a role for systemic modelling was suggested. Second moments of area, indicative of bending rigidity, are additionally influenced by the moment arm length, which for midshaft locations, will be proportional to bone lengths (Ruff 2000); second moments of area should thus be standardized to the product of body mass and the second power of bone length. Variation in body shape (relative body breadth to stature) will also influence the biomechanics of the limb (Ruff 1995a, 2000, Stock 2006). Signatures of mobility appear most strongly in distal limb segments (e.g. at the midshaft tibia cross-section), whilst influences of relative body breadth can be detected at least as far as midshaft femur sections (Ruff et al. 2006b, Stock 2006).

(b) What type of strain? Magnitude vs. frequency

There is debate as to whether bone responds only to strains of high magnitude, or whether low magnitude strains of a greater frequency (i.e. repetitiveness) can lead to bone modelling. This is important to the study of mobility from the skeleton because locomotor behaviours are likely to be highly repetitive over an individual's lifecycle, but may not necessarily be high in magnitude. Frost (1987, 1988, 1997) argues that unless forces exceed a particular threshold level, strains will create micro-damage that can be repaired without necessitating any increase in bone mass or strength. In contrast, Rubin and colleagues have documented increased density of trabecular bone in the proximal femur of sheep in response to low magnitude, high frequency loading (Rubin et al. 2001). An aspect to this debate is whether marathon runners have robust or gracile limbs, since their bones are subject to relatively low magnitude but high frequency loading (Frost 1997). Marathon runners would be regarded as highly mobile individuals, so if such repetitive loading is insufficient to trigger increased bone deposition, there would be a significant concern for studies of mobility patterns prehistorically. However, Duncan et al. (2002) have observed higher second moments of area at the femur midshaft among female runners when compared to swimmers, cyclists, or controls. Shaw and Stock (2009b) also demonstrate that loading amongst runners lead to anteroposteriorly (front-to-back) strengthened diaphyses (i.e. in response to activity, cross-sectional shape becomes less circular). In contrast, hockey players, who load their limbs in a greater variety of directions than distance runners, show strengthened bones to multidirectional loading, with ratios such as I_x/I_y producing lower values, more similar to controls (Figure 7.4). These observations suggest that subsistence activities such as hunting or foraging over wide ranges, or high residential mobility, should be sufficient to alter bone morphology, leading to signatures engrained in the skeleton.

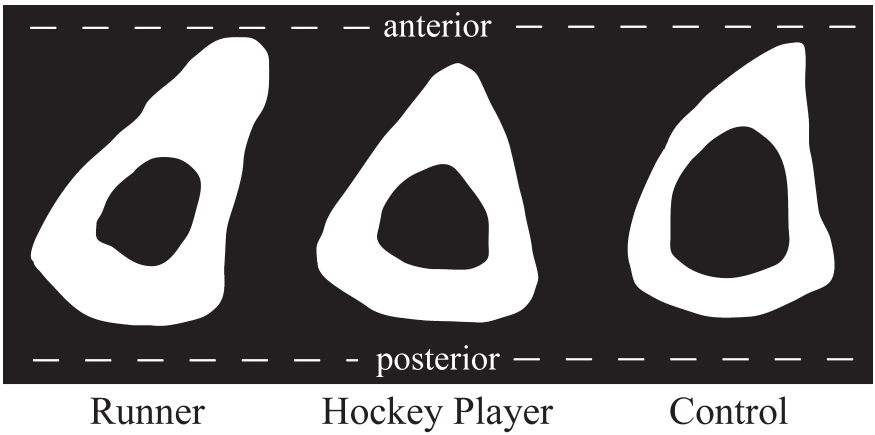


Figure 7.4 Example tibia midshaft cross-sections for runners, hockey players, and controls. Runners show anteroposteriorly strengthened cross-sections, whilst hockey players show strengthening in multiple directions, relative to controls

Source: Adapted from Shaw and Stock 2009a: figure 3.

(c) When is the skeleton most sensitive to the effects of mobility?

Cross-sectional morphology is also influenced by age both during growth and through a continued response in adulthood. A range of studies have found evidence supporting the suggestion that diaphyseal properties are largely a reflection of load-bearing during the later stages of growth (Daly et al. 2004, van der Meulen et al. 1993, 1996, Nanyan et al. 2005, Ruff et al. 1994). The most important influences on skeletal morphology occur just prior to skeletal maturity (Kannus et al. 1995), which suggests that skeletal signatures reveal insights into mobility that may occur relatively early in adult life, with more limited responses in adulthood.

Later in life, aging leads to endosteal resorption (bone loss from the inner surface) and cortical thinning, particularly among females (Ruff and Hayes 1983, 1988). Humeri of older adults within a skeletal sample have been shown to display larger external dimensions reflecting continued bone apposition (Pfeiffer 1980, Lazenby 1990a, b). Evidence supporting periosteal (outer surface) expansion of long bones with aging may mechanically compensate for endosteal resorption, particularly since it is the bone further from the centre of the cross-section which makes the greatest contribution to its mechanical properties (Ruff and Hayes 1982, Lazenby 1990a). It should be noted however that, at least in part, these age-related changes in bone cross-sectional morphology may also be attributed to remodelling arising from activity and behaviour occurring throughout adulthood.

Bone density also decreases during adulthood, leading to progressive bone fragility (Gosman et al. 2011). Szulc et al. (2006) have demonstrated that endosteal bone loss and periosteal apposition maintain bone bending strength in premenopausal women, but post-menopause, the balance fails as endocortical bone loss increases and periosteal apposition decreases. Increased bone fragility is associated with sex hormone deficiency and secondary hyperparathyroidism (Gosman et al. 2011). Whilst aging will influence the morphology of the skeleton, comparisons are valid between groups of adults, as long as care is taken to ensure old (over-50s) individuals are excluded. Significant differences in demographic profiles is also worthy of consideration in ensuring significant results do reflect behavioural differences, but the problems do not invalidate the approach.

(d) Localized vs. systemic responses to loading

One important consideration is the extent to which functional loading produces localized remodelling of bone or whether the underlying physiological processes (which remain comparatively poorly understood: see Gosman et al. 2011 for review) are more systemic in nature. In other words, does activity lead to a general increase in robusticity across the whole skeleton, or are bone responses to loading much more confined to specific parts of the skeleton where the loads are experienced most strongly (e.g. midshafts of the limb bones)?

There is evidence that cortical bone strength becomes 'site-specifically adapted to local and more distant mechanical forces by the selective and strategic distribution of bone mass and shape' (Gosman et al. 2011). Lieberman et al. (2001) tested bone's responses to loading experimentally in sheep and observed significant differences in diaphyseal cross-sectional properties between exercised and control groups, but no significant differences in articular surface area. Insights from experimental studies have also suggested that bone deposition in response to functional loading does occur in unloaded regions of the skeleton, as well as at key diaphyseal sites, as observed with increased cranial thickness among exercised pigs and armadillos (Lieberman 1996). Functional loading of a single bone also results in adaptation that involves multiple bones (Rubin and Rubin 2008). Simulations of cortical bone development in the rat tibia have suggested that the combination and interaction of far-field loads (body mass) and local periosteal surface loads from adjacent muscle activity are both important to cortical bone cross-sectional morphology (Carpenter and Carter 2008, Gosman et al. 2011, Schoenau and Frost 2002 for review).

For human skeletal remains, the correlation of upper limb morphology with body mass through the same scaling relationships as for the lower limb can also be regarded as support for systemic mechanisms in bone remodelling. In contrast, that the skeletal response to behaviours is greater at a local level as opposed to being entirely systemic was a hypothesis tested in human skeletal remains by Stock and Pfeiffer (2001). The observation of increased relative upper limb rigidity in Andaman Islanders, and relatively increased lower limb rigidity in LSA South Africans, consistent with functional expectations regarding upper

and lower limb-dominated mobility (i.e. paddling watercraft *vs*. walking on land), reflects localized adaptation (Figure 7.5). Within the lower limb, distal locations appear to retain stronger signatures of behavioural variation than can be observed proximally in the limb. This result suggests that the midshaft of the tibia in particular is an important location in the lower limb for the detection of mobility skeletally (Stock 2006); whilst in the proximal limb (closer to the pelvis) constraints upon the morphology associated with body shape variation appear to exert greater influence (Ruff et al. 2006b, Stock 2006, Weaver 2002).

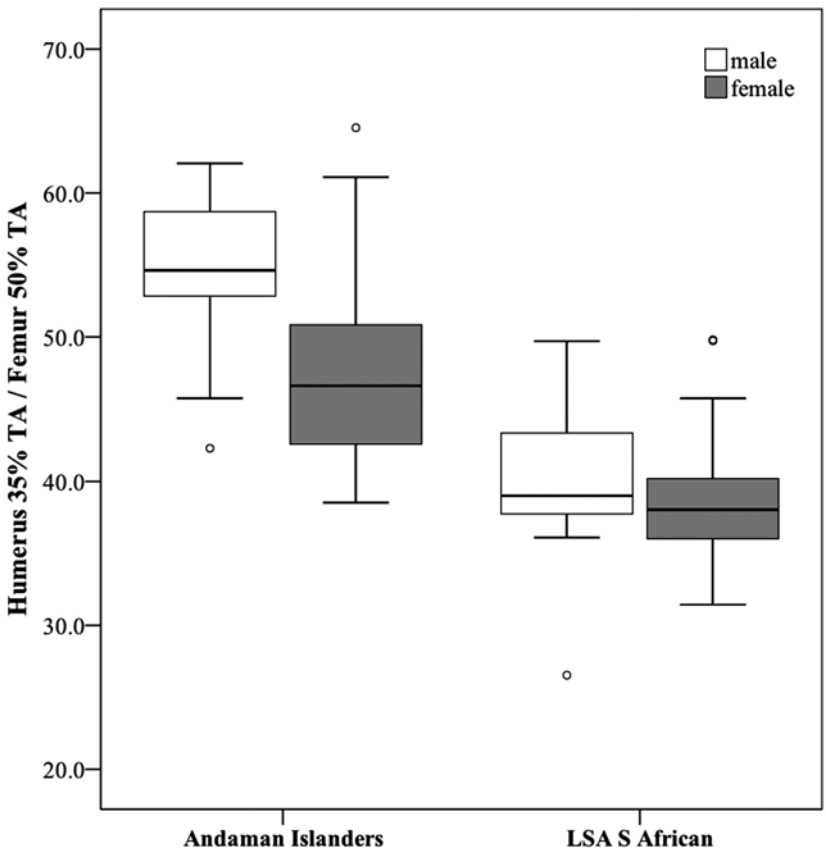


Figure 7.5 Humero-femoral TA ratio (Humerus 35 per cent/femur 50 per cent) among Andaman Islanders and LSA South Africans. Higher ratios observed among the Andaman Islanders relative to the LSA South Africans indicate increased humeral strength relative to the femur, likely associated with use of watercraft in the former group *vs*. high terrestrial mobility in the latter

(e) Can diverse populations be compared?

Genetics vs. functional adaptation

Whilst the functional adaptation of bone morphology to loading has been supported from a variety of sources, it is important to also recognize the role of genetic processes in the morphology of the limbs and the potential influence of genetic differences on inter-population variation in bone cross-sectional properties. Volkman et al. (2003, 2004) examine the effects of polymorphic genes on bone size, shape and mechanical integrity in mice and were able account for about 3–22 per cent of trait variances through genes. Lovejoy et al. (2003) have also highlighted the roles genetics can play in determining bone morphology.

Lovejoy and colleagues (Ohman et al. 2000, Ohman and Lovejoy 2001, 2003) have suggested that growth plate shape may be an important determinant of cross-sectional geometry of diaphyses. However, Holden and Ward (2003) counter Ohman et al.'s (2000) arguments in a study of metacarpals that found no correlation between growth plates and the shape of the diaphyses at midshaft, whilst Nalley and Ward (2003) observed a similar pattern for femoral midshaft external dimensions. As Ruff et al. (2006a) review, the majority of evidence suggests midshaft morphology is highly independent from growth plate shape, which is under much greater genetic constraint.

Studies of ontogeny have suggested population differences in postcranial robusticity appear very early in development (c.f. Stock 2009, Cowgill 2010) implying that genetic propensities may play a role within a 'complex mosaic of processes' (Cowgill 2010: 16) that result in adult postcranial robusticity. It is also apparent that genetics impacts the responsiveness of the physiological mechanisms that respond to the impacts of functional loading (Gosman et al. 2011, Kesavan et al. 2006, Kodama et al. 2000, Lagerholm et al. 2010, Masinde et al. 2003, Wergedal et al. 2005). Wallace et al. (2010) observe that the diaphyseal morphology in mice artificially selected for increased locomotion retains an evolutionary signature; demonstrating that both functional and evolutionary components may be reflected in diaphyseal morphology. It remains otherwise fairly unclear whether genetic differences among modern humans are sufficient to generate differences that prevent the comparison of geographically or temporally distinct populations. However, a weight of evidence supports the high level of plasticity in the skeleton, and particularly where loading may be high, it can be reasonably expected that functional differences will erode any underlying genetic distinctions.

The effects of terrain

External influences of the physical environment may also impact limb morphology; one key trait to consider is terrain. Ruff (1995b) tested the possible influence of terrain upon bone cross-sectional properties in an analysis of eight Amerindian pre- and proto-historic populations. He observed much higher correlations with cross-sectional geometry for terrain (mountainous, plains, coastal) than for either sex or subsistence economy. However, the orientations of loadings (calculated

as cross-sectional shape) were more determined by behaviours (i.e. mobility). Furthermore, an influence of terrain does not necessarily mask signatures of mobility, and indeed interaction can reveal useful insights. Marchi and colleagues (2006, 2008) have asserted the influence of mountainous terrain as accounting for unexpectedly high values of limb bone rigidity in Neolithic males in Western Liguria. It appears males were adapted to the rugged terrain to a greater extent than observed amongst females, suggesting pastoralist mobility among males. Using an animal model, Higgins (2011) discusses the influence of terrain on cross-sectional geometry of bovid taxa. Support for the hypothesis that Neanderthal tibia are mediolaterally robust as an adaptation to locomotion on rugged terrain was observed in the increased robusticity, and especially pronounced mediolateral rigidity and strength of mountainous *vs*. flat terrain bovids.

Skeletal insights into mobility and archaeological applications to prehistory

I. Testing archaeological hypotheses: Palaeolithic and Holocene European prehistory

European Prehistory, from Neanderthals and the earliest anatomically modern humans of the Upper Palaeolithic has provided an archaeological setting suited to the study of behavioural changes set against archaeological context. Archaeological insights into mobility, particularly in the Pleistocene or early Holocene, can rely heavily upon available evidence for settlements or exchange of materials. The skeletal morphology either of fossilized individuals, or of more recent samples associated with specific archaeological contexts, provides an alternative means to gain insights into overall mobility levels, and to test predictions from hypotheses grounded in the archaeology.

Concerning broad regional patterns and long timescales, a recent synthesis of material from across the Palaeolithic (Trinkaus and Ruff 2012) examined shape ratios of the lower limb at five intervals across each of the femur and tibia. Marked changes particularly across the midshaft regions of each bone were observed. Archaic hominins (Neanderthals, Early and Middle Pleistocene individuals) particularly show greater relative mediolateral bending rigidity that likely derives from shifts in pelvic and proximal femur proportions through the Pleistocene (Trinkaus and Ruff 2012).

Early modern humans in Europe may be skeletally gracile in comparison to Neanderthals, but biomechanical studies suggest further decreases in bone robusticity indicating a progressive decline in levels of mobility between the Early Upper Palaeolithic and the Mesolithic. The Early Upper Palaeolithic is characterized by individuals displaying increased bending strength relative to the Mesolithic and significantly less circular cross-sectional shape relative to either Late Upper Palaeolithic or Mesolithic (Holt 2003). A similar pattern has also been confirmed more broadly across the Old World (Shackelford 2007). These studies

support an interpretation of declining mobility across the Upper Palaeolithic, perhaps highlighting increased sedentism or decreased range size of the later populations relative to the earliest modern humans entering Europe 40,000 years ago. The results lend support to archaeological evidence of changing foraging behaviours in response to the onset of the last glacial maximum (Holt 2003, Shaw and Stock 2013).

In more localized contexts, a range of studies have also highlighted aspects of mobility testing or developing archaeological models. High robusticity in the Neolithic of Northern Liguria, inconsistent with other Neolithic samples across Europe, and more in line with highly mobile Palaeolithic individuals, has been interpreted as reflecting pastoralist subsistence, giving rise to high mobility across rugged, mountainous environments (Marchi et al. 2006, Marchi 2008). In Central Europe, Sladek et al. (2006a, b) evaluated two contrasting hypotheses concerning mobility in the Late Eneolithic (Corded Ware archaeological culture) arising from the archaeological settlement record in the region, interpreted as evidence for either mixed agricultural subsistence or a pastoralist subsistence strategy. The skeletal data did not support elevated levels of mobility in the Late Eneolithic relative to the Early Bronze Age, and rather suggested more of a mosaic between samples included (Sladek et al. 2006a, b). These studies demonstrate how cross-sectional geometry can provide behavioural insights into variable archaeological contexts, or an independent test of hypotheses drawn from archaeological evidence such as settlement distributions.

Finally, on an individual scale, the extensive biomechanical study of the Tyrolean 'Iceman', Otzi, observed strength properties of his limbs consistent with mediolateral strengthening in the femur in response to a broad body, but anteroposteriorly strengthened tibia that implies high mobility, given the geographical context, likely over rough terrain (Ruff et al. 2006b). Otzi is a well-known mummified skeleton dated to the late Neolithic (5200 BP) found at an altitude of 3200 m in the Tyrolean Alps. The biomechanic analysis supports other archaeological evidence indicating that this individual was likely to have been a highly mobile pastoralist. It is suggested that pastoralist mobility in this mountainous region may explain why, in isolation, his limbs appear more similar to more mobile Mesolithic than Neolithic males.

II. Diachronic change: The transition to agriculture in Egypt

The robusticity of the limbs can further provide a route to evaluate the impact of major social and economic transitions upon the lives of past peoples. The transition to agriculture is one of the most significant phases in prehistory. Skeletal evidence is often a source of understanding the impact of subsistence change upon the health and disease of populations (Cohen and Armelagos 1984, Starling and Stock 2007). However, this is also an important phase in which to examine mobility and individuals' wider interactions with their environments.

The transition to agriculture and the development of the Egyptian state in the Nile Valley provides a suitable case to explore transitions in mobility levels with cultural change. A record of hunter-gatherers in the late Pleistocene (e.g. Jebel Sahaba) is succeeded by a Predynastic/Neolithic period beginning 5500 BC that displays evidence for transition from nomadic pastoralism to agriculture (Kemp 1989, Stock et al. 2011). Subsequently, in Dynastic phases there is further development of agriculture, task specialization, hierarchy and expansion of empire. These phases of transition are well documented, which has allowed the subsequent assessment of skeletal biology (Starling and Stock 2007, Stock et al. 2011, Zakrzewski 2003, 2007).

Stock et al. (2011) examine the skeletal evidence for changing mobility patterns between populations over the course of agricultural and state development in the Nile basin. They examined the skeletal morphology of Jebel Sahaba hunter-gatherers (13,000–9000 BC), pre-dynastic Egyptian el-Badari early agriculturalists (5000–4000 BC), the pre-dynastic Hierakonpolis sample (4000–3000 BC) and twelfth Dynasty Nubian agriculturalists (2100–1500 BC). Cross-sectional properties indicated a reduction in humeral and femoral strengths between Jebel Sahaba hunter-gatherers and the el-Badari early agriculturalists. Among females a reduction occurs only later for femoral strength. These patterns suggest complex sexual division of labour and its changing dimensions through time. These samples span a wide geographic and temporal range and further insights into diversity between communities and other regions that fell within the influence of the Egyptian state may reveal further, more refined insights.

IIb. Whole limb morphological change

Recent technological advances now facilitate a more comprehensive, whole bone assessment of bone rigidity (Davies et al. 2012, Shaw and Ryan 2011). This enables an evaluation of how bone morphology of the whole diaphysis responds to mobility changes arising from subsistence changes. This echoes early studies of biomechanic properties (Ruff and Hayes 1983) that considered variation at 11 sites across the limb, but the resolution now available is much greater (here sections are examined at every 1% of bone length). Three-dimensional laser scanning provides a means to perform analyses at such a high resolution, thanks to advanced automation in the calculation of biomechanical properties. This approach currently applies a solid model of bone cross-sections (with no accounting for the impact of the medullary cavity). Future applications may be able to integrate endosteal x-ray assessments, or model endosteal contour effects, but it is the periosteal geometry of a bone that is the most critical to its mechanical competence (Bertram and Swartz 1991). The solid model, periosteal-only approach, provides an estimation of true properties but one that has been shown to share close resemblance to true values (Macintosh et al. 2013, Stock and Shaw 2007, Sparacello and Pearson 2010, Davies et al. 2012).

Preliminary whole-limb results for populations from el-Badari and Kerma are presented in Figures 7.6 and 7.7. As noted above, the el-Badari are from an

early agricultural site, showing evidence of plant and animal domestication but no evidence of permanent settlement, and they have been characterized consequently as perhaps practising nomadic pastoralism. In contrast, the site of Kerma, in Nubia, is a fully agriculturalist settlement in the well-developed twelfth Dynastic Egyptian state. The el-Badari sample is composed of only a small number of individuals (femur: 3 males, 5 females; tibia: 1, 3) and thus any conclusions must be drawn with caution. Nevertheless, the Kerman males show largest values of total subperiosteal area (Figure 7.6) in all but the proximal femur, and particularly increased robusticity across the tibia. The lines show that any differences in midshaft sites are also reflected across the whole of the lower limb in a very consistent manner. The Kermans have on average greater total subperiosteal area in the tibia relative to the femur, which may be detecting a particular behavioural influence acting upon the whole tibia, but less so (or clouded by other variables) across the femoral shaft. One can also examine the pattern of sexual dimorphism, for which Kermans show greater dimorphism than the small variation among the el-Badari. This could tentatively be used to suggest a development of greater division of labour through the time period separating these two sites, or at least greater variance in the levels of mobility, although confirmation will require the assessment of further samples from the region.

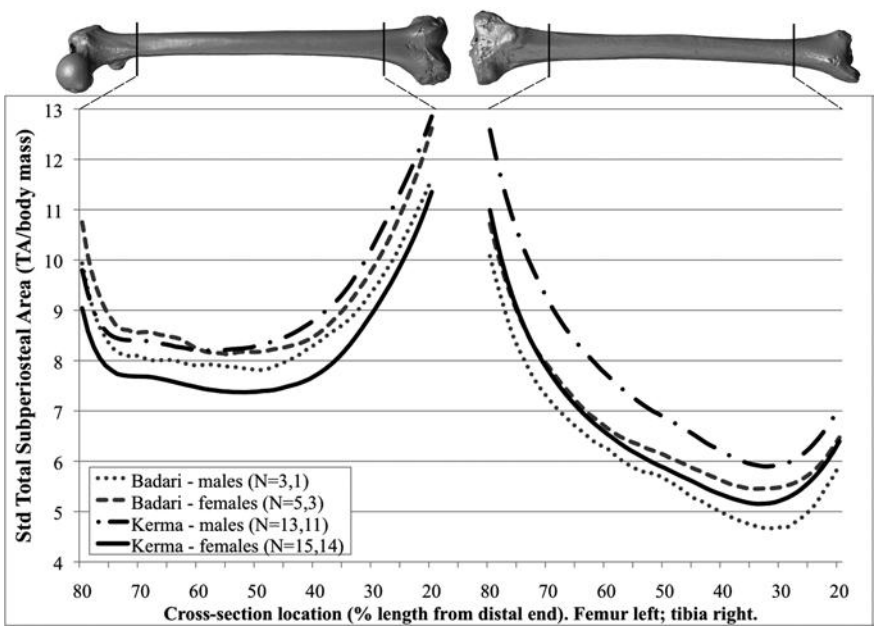


Figure 7.6 Mean total subperiosteal area (standardized to body mass) across the lower limb among males and females from the el-Badari and Kerma populations, measured at 1 per cent intervals of bone length

As discussed above, cross-sectional shape indices also provide a good indicator of prehistoric mobility. Figure 7.7 plots the I_x/I_y shape ratio across the lower limb. The el-Badari early agropastoralists show elevated ratios in the proximal tibia suggesting that whilst they do not possess overall greater rigidity to torsional or compressive strength, the bending rigidity is relatively greater anteroposteriorly (i.e. in line with direction of mobility). There is only a single el-Badari male tibia, but that individual does show a higher ratio than the three other sample means across the whole length of the tibial shaft. In the femur, Kerma males show a modest increased ratio over females only in the midshaft (60–30 per cent) region of the bone, suggesting that the elevated overall rigidity among Kerma males (Figure 7.7) can be attributed to anteroposterior loading, in line with expectation for the effects of terrestrial mobility (c.f. Shaw and Stock 2009b). These results compare just two specific skeletal collections representing small samples of individuals from across the agricultural transition in Egypt. However, they demonstrate the applicability of a method and provide early indications concerning mobility patterns inferred from skeletal signatures that can be further tested through direct comparison to predictions arising from other sources of archaeological data.

Figure 7.7 Mean I_x/I_y shape ratio across the lower limb (1 per cent intervals of bone length) among males and females from the el-Badari and Kerma populations

These results first demonstrate how midshaft indicators of mobility are representative of changes to the wider skeletal structure across the whole limb. This is important because measures of biomechanical properties at midshafts are by far the most commonly employed so it is important to demonstrate this location is representative of the properties of the shaft more generally. This approach also offers the potential to identify regions of the bone that may be particularly revealing in terms of mechanical loading, and thus reveal further insights into subsistence behaviours, and mobility with regards to that. In the case of el-Badari and Kerma, the whole limb morphology presents similar trends, but comparisons of more diverse populations must deal further with variation arising from body size and shape, or other non-behavioural influences upon bone morphology.

Future directions

This chapter has focused upon only biomechanical signatures of mobility in cross-sectional geometry. Other skeletal indicators of activity and mobility include: bone curvature (De Groote 2008, 2011), humeral torsion (Rhodes and Churchill 2009), or epiphyseal evulsion (Villotte et al. 2010). Whilst the study of ancient biomolecules and isotopes has attained much greater traction across archaeology, it is important to test such insights against the physiological signatures retained in bone macromorphology to give a more complete view of past mobility. Isotopic and biomolecular methods generally reflect mobility on a different level (i.e., significant moves of residential location) while biomechanics indicate mobility on a habitual level, so together they offer potential for a more refined view of mobility at different scales within the lifespan. Future work must seek to integrate insights from across the skeleton, in order to reveal more specific indications, reveal insights into specific activities, and develop our understanding of the processes underlying skeletal morphology, or signatures that may be retained in features such as trabecular bone, or 3D finite element analyses of bone properties.

Conclusions

Whilst skeletal biology may be complex and retains information attributable to a variety of factors, functional adaptation means that loading, particularly that experienced during adolescence, creates signatures of overall activity level within the skeleton. Both repetitive and high magnitude behaviours leave signals in bone morphology. Signatures of terrestrial mobility are engrained in the lower limb that can be used to test predictions arising from archaeological evidence, whilst the relative strength of the humerus to femur can provide an indication of the degree of marine mobility. This chapter has illustrated the impact that mobility has upon skeletal robusticity, highlighting how, through adaptation, mobility is an embodied

action, and an action that can be inferred from the skeleton in order to reconstruct elements of the lives of individuals and populations in the past.

References

Bass, S., Saxon, L. and Daly, R. 2002. The effect of mechanical loading on the size and shape of bone in pre-, peri-, and postpubertal girls: A study in tennis players. *Journal of Bone and Mineral Research*, 17, 2274–80.

Bertram, J.E.A. and Swartz, S.M. 1991. The 'Law of Bone Transformation' : A case of crying Wolff? *Biological Reviews*, 66, 245–73.

Biewener, A.A. and Bertram, J.E.A. 1994. Structural response of growing bone to exercise and disuse. *Journal of Applied Physiology*, 76, 946.

Bridges, P.S. 1989. Changes in activities with the shift to agriculture in the Southeastern United-States. *Current Anthropology*, 30, 385–94.

Bridges, P.S., Blitz, J.H. and Solano, M.C. 2000. Changes in long bone diaphyseal strength with horticultural intensification in West-Central Illinois. *American Journal of Physical Anthropology*, 112, 217–38.

Carpenter, R. and Carter, D. 2008. The mechanobiological effects of periosteal surface loads. *Biomechanics and Modeling in Mechanobiology*, 7, 227–42.

Cohen, M. and Armelagos, G. (eds). 1984. *Paleopathology at the Origins of Agriculture*. Orlando: Academic Press.

Cowgill, L.W. 2010. The ontogeny of Holocene and Late Pleistocene human postcranial strength. *American Journal of Physical Anthropology*, 141, 16–37.

Daly, R.M., Saxon, L., Tumer, C.H., Robling, A.G. and Bass, S.L. 2004. The relationship between muscle size and bone geometry during growth and in response to exercise. *Bone*, 34, 281–7.

Davies, T.G., Shaw, C.N. and Stock, J.T. 2012. A test of a new method and software for the rapid estimation of cross-sectional geometric properties of long bone diaphyses from 3D laser surface scans. *Archaeological and Anthropological Sciences*, 4(4), 277–90.

Duncan, C.S., Blimkie, C.J.R., Kemp, A., Higgs, W., Cowell, C.T., Woodhead, H., Briody, J.N. and Howman-Giles, R. 2002. Mid-femur geometry and biomechanical properties in 15- to 18-yr-old female athletes. *Medicine and Science in Sports and Exercise*, 34, 673–81.

Endo, B. and Kimura, T. 1970. Postcranial skeleton of the Amud man, in *The Amud Man and his Cave Site*, edited by H. Suzuki and F. Takai. Tokyo: Academic Press, 231–406.

Frost, H.M. 1987. Bone 'mass' and the 'mechanostat': A proposal. *The Anatomical Record*, 219, 1–9.

Frost, H.M. 1988. Vital biomechanics: Proposed general concepts for skeletal adaptations to mechanical usage. *Calcified Tissue International*, 42, 145–56.

Frost, H.M. 1997. Why do marathon runners have less bone than weight lifters? A vital-biomechanical view and explanation. *Bone*, 20, 183–9.

Gosman, J.H., Stout, S.D. and Larsen, C.S. 2011. Skeletal biology over the life span: A view from the surfaces. *Yearbook of Physical Anthropology*, 54, 86–98.

De Groote, I.E.P.M. 2008. *A Comprehensive Analysis of Long Bone Curvature in Neanderthals and Modern Humans Using 3D morphometrics*. Unpublished Ph.D. Dissertation, University College London.

De Groote, I.E.P.M. 2011. Femoral curvature in Neanderthals and modern humans: A 3D geometric morphometric analysis. *Journal of Human Evolution*, 60, 540–8.

Haapasalo, H., Kontulainen, S., Sievanen, H., Kannus, P., Jarvinen, M. and Vuori, I. 2000. Exercise-induced bone gain is due to enlargement in bone size without a change in volumetric bone density: A peripheral quantitative computed tomography study of the upper arms of male tennis players. *Bone*, 27, 351–7.

Hawkey, D.E. and Merbs, C.F. 1995. Activity-induced musculoskeletal stress markers (MSM) and subsistence strategy changes among ancient Hudson Bay Eskimos. *International Journal of Osteoarchaeology*, 5(4), 324–38.

Higgins, R.W. 2011. Long bone cross-sectional shape and robusticity in mountainous and flat terrain bovids: implications for Neandertal locomotor behavior. *American Journal of Physical Anthropology Supplement*, 144(S52), 162–3.

Holden, A. and Ward, C. 2003. The effects of epiphyseal shape on metacarpal diaphyseal proportions in hominoids: Implications for long bone growth. *American Journal of Physical Anthropology Supplement*, 120(S36), 116.

Holt, B.M. 2003. Mobility in Upper Paleolithic and Mesolithic Europe: Evidence from the lower limb. *American Journal of Physical Anthropology*, 122, 200–15.

Huiskes, R. 1982. On the modelling of long bones in structural analyses. *Journal of Biomechanics*, 15, 1.

Jones, H.H., Priest, J.D., Hayes, W.C., Tichenor, C.C. and Nagel, D.A. 1977. Humeral hypertrophy in response to exercise. *The Journal of Bone and Joint Surgery*, 59, 204–8.

Kannus, P., Haapasalo, H., Sankelo, M., Sievanen, H., Pasanen, M., Heinonen, A., Oja, P. and Vuori, I. 1995. Effect of starting age of physical activity on bone mass in the dominant arm of tennis and squash players. *Annals of Internal Medicine*, 123, 27–31.

Kemp, B.J. 1989. *Ancient Egypt: Anatomy of a Civilization*. London: Routledge.

Kesavan, C., Mohan, S., Srivastava, A., Kapoor, S., Wergedal, J., Yu, H. and Baylink, D.J. 2006. Identification of genetic loci that regulate bone adaptive response to mechanical loading in C57BL/6J and C3H/HeJ mice intercross. *Bone*, 39, 634–43.

Koch, J.C. 1917. The laws of bone architecture. *American Journal of Anatomy*, 21, 177–298.

Kodama, Y., Umemura, Y., Nagasawa, S., Beamer, W.G., Donahue, L.R., Rosen, C.R., Baylink, D.J. and Farley, J.R. 2000. Exercise and mechanical loading increase periosteal bone formation and whole bone strength in C57BL/6J mice but not in C3H/Hej mice. *Calcified Tissue International*, 66, 298–306.

Lagerholm, S.H.P., Luthman, H., Nilsson, M., McGuigan, F., Swanberg, M. and Akesson, K. 2010. Genetic loci for bone architecture determined by three-dimensional CT in crosses with the diabetic GK rat. *Bone*, 47, 1039–47.

Lanyon, L.E. and Baggott, D.G. 1976. Mechanical function as an influence on the structure and form of bone. *The Journal of Bone and Joint Surgery*, 58(B), 436–43.

Lanyon, L.E. and Bourn, S. 1979. The influence of mechanical function on the development and remodelling of the tibia. An experimental study in sheep. *The Journal of Bone and Joint Surgery*, 61, 263–73.

Larsen, C.S. 1981. Functional implications of postcranial size reduction on the prehistoric Georgia coast, USA. *Journal of Human Evolution*, 10, 489–502.

Larsen, C.S. 1999. *Bioarchaeology: Interpreting Behaviour from the Human Skeleton*. Cambridge: Cambridge University Press.

Lazenby, R.A. 1990a. Continuing periosteal apposition I: Documentation, hypotheses, and interpretation. *American Journal of Physical Anthropology*, 82, 451–72.

Lazenby, R.A. 1990b. Continuing periosteal apposition II: The significance of peak bone mass, strain equilibrium, and age-related activity differentials for mechanical compensation in human tubular bones. *American Journal of Physical Anthropology*, 82, 473–84.

Lieberman, D.E. 1996. How and why humans grow thin skulls: Experimental evidence for systemic cortical robusticity. *American Journal of Physical Anthropology*, 101, 217–36.

Lieberman, D.E., Devlin, M.J. and Pearson, O.M. 2001. Articular area responses to mechanical loading: Effects of exercise, age, and skeletal location. *American Journal of Physical Anthropology*, 116, 266–77.

Lieberman, D.E., Pearson, O.M., Polk, J.D., Demes, B. and Crompton, A.W. 2003. Optimization of bone growth and remodelling in response to loading in tapered mammalian limbs. *The Journal of Experimental Biology*, 206, 3125–38.

Lovejoy, C.O. and Trinkaus, E. 1980. Strength and robusticity of the Neandertal tibia. *American Journal of Physical Anthropology*, 53, 465–70.

Lovejoy, C.O., Burstein, A.H. and Heiple, K.G. 1976. The biomechanical analysis of bone strength: A method and its application to platycnemia. *American Journal of Physical Anthropology*, 44, 489–506.

Lovejoy, C.O., McCollum, M.A., Reno, P.L. and Rosenman, B.A. 2003. Developmental biology and human evolution. *Annual Review of Anthropology*, 32, 85–109.

Macintosh, A., Davies, T., Ryan, T.M., Shaw, C.N. and Stock, J.T. 2013. Periosteal *vs*. true cross-sectional geometry: A comparison along humeral, femoral, and tibial diaphyses. *American Journal of Physical Anthropology*, 150(3), 442–52.

Marchi, D. 2008. Relationships between lower limb cross-sectional geometry and mobility: The case of a Neolithic sample from Italy. *American Journal of Physical Anthropology*, 137, 188–200.

Marchi, D., Sparacello, V.S., Holt, B.M. and Formicola, V. 2006. Biomechanical approach to the reconstruction of activity patterns in Neolithic Western Liguria, Italy. *American Journal of Physical Anthropology*, 131, 447–55.

Masinde, G., Wergedal, J., Davidson, H., Mohan, S., Li, R., Li, X. and Baylink, D.J. 2003. Quantitative trait loci for periosteal circumference (PC): Identification of single loci and epistatic effects in F2 MRL/SJL mice. *Bone*, 32, 554–6.

Meulen, M.C.H. van der, Beaupre, G.S. and Carter, D.R. 1993. Mechanobiologic influences in long bone cross-sectional growth. *Bone*, 14, 635–42.

Meulen, M.C.H. van der, Ashford, M.W.J., Kiratli, B.J., Bachrach, L.K. and Carter, D.R. 1996. Determinants of femoral geometry and structure during adolescent growth. *Journal of Orthopaedic Research*, 14, 22–29.

Nalley, T. and Ward, C.V. 2003. The effects of epiphysis shape on femoral diaphyseal proportions in hominoids. *American Journal of Physical Anthropology Supplement*, 120(S36), 156–7.

Nanyan, P., Prouteau, S., Jaffre, C., Benhamou, L. and Courteix, D. 2005. Thicker radial cortex in physically active prepubertal girls compared to controls. *International Journal of Sports Medicine*, 26, 110–5.

Nikander, R., Sievanen, H., Uusi-Rasi, K., Heinon, A. and Kannus, P. 2006. Loading modalities and bone structure at nonweight-bearing upper extremity and weight-bearing lower extremity: A pQCT study of adult female athletes. *Bone*, 39, 886–94.

Ohman, J.C. and Lovejoy, C.O. 2001. The shape of a long bone's shaft: Bending stress or growth plate form? *American Journal of Physical Anthropology Supplement*, 114(S32), 115.

Ohman, J.C. and Lovejoy, C.O. 2003. Asymmetry in the humeri of tennis players: "Wolff"s Law' or not? *American Journal of Physical Anthropology Supplement*, 120(S36), 161.

Ohman, J.C., Lovejoy, C.O., Simpson, S.W. and Latimer, B. 2000. Skeletal variability and functional morphology. *American Journal of Physical Anthropology Supplement*, 11(S30), 242–3.

Pearson, O.M. and Lieberman, D.E. 2004. The aging of Wolff's 'law': Ontogeny and responses to mechanical loading in cortical bone. *Yearbook of Physical Anthropology*, 47, 68–99.

Pfeiffer, S. 1980. Age changes in the external dimensions of adult bone. *American Journal of Physical Anthropology*, 52, 529–32.

Rhodes, J.A. and Churchill, S.E. 2009. Throwing in the Middle and Upper Palaeolithic: Inferences from an analysis of humeral retroversion. *Journal of Human Evolution*, 56, 1–10.

Rubin, C.T. 1984. Skeletal strain and the functional significance of bone architecture. *Calcified Tissue International*, 36, S11–S18.

Rubin, C.T. and Lanyon, L.E. 1984. Regulation of bone formation by applied dynamic loads. *The Journal of Bone and Joint Surgery*, 66A(3), 397–402.

Rubin, C.T. and Lanyon, L.E. 1987. Osteoregulatory nature of mechanical stimuli: Function as a determinant for adaptive remodeling in bone. *Journal of Orthopaedic Research*, 5, 300–10.

Rubin, C.T. and Rubin, J. 2008. Functional adaptation to loading of a single bone is neuronally regulated and involves multiple bones. *Journal of Bone and Mineral Research*, 23, 1369–71.

Rubin, C.T., Turner, A.S., Bain, S., Mallinckrodt, C. and McLeod, K. 2001. Anabolism. Low mechanical signals strengthen long bones. *Nature*, 412, 603–4.

Ruff, C.B. 1984. Allometry between length and cross-sectional dimensions of the femur and tibia in Homo sapiens sapiens. *American Journal of Physical Anthropology*, 65, 347–58.

Ruff, C.B. 1995a. Biomechanics of the hip and birth in early Homo. *American Journal of Physical Anthropology*, 98, 527–74.

Ruff, C.B. 1995b. Limb bone structure: influence of sex, subsistence, and terrain [Abstract]. *American Journal of Physical Anthropology Supplement*, 38(S1), 186.

Ruff, C.B. 2000. Body size, body shape, and long bone strength in modern humans. *Journal of Human Evolution*, 38, 269–90.

Ruff, C.B. 2008. Biomechanical analyses of archaeological human skeletal samples, in *Biological anthropology of the human skeleton*, edited by M. Katzenberg and A. Saunders. New York: Wiley, 183–206.

Ruff, C.B. and Hayes, W.C. 1982. Subperiosteal expansion and cortical remodeling of the human femur and tibia with aging. *Science*, 217, 945–8.

Ruff, C.B. and Hayes, W.C. 1983. Cross-sectional geometry of Pecos Pueblo femora and tibiae – a biomechanical investigation: II. Sex, age, side differences. *American Journal of Physical Anthropology*, 60, 383–400.

Ruff, C.B. and Hayes, W.C. 1988. Sex differences in age-related remodeling of the femur and tibia. *Journal of Orthopaedic Research*, 6, 886–96.

Ruff, C.B., Larsen, C.S. and Hayes, W.C. 1984. Structural changes in the femur with the transition to agriculture on the Georgia coast. *American Journal of Physical Anthropology*, 64, 125–36.

Ruff, C.B., Trinkaus, E., Walker, A. and Larsen, C.S. 1993. Postcranial robusticity in Homo. I: Temporal trends and mechanical interpretation. *American Journal of Physical Anthropology*, 91, 21–53.

Ruff, C.B., Walker, A. and Trinkaus, E. 1994. Postcranial robusticity in Homo. III: Ontogeny. *American Journal of Physical Anthropology*, 93, 35–54.

Ruff, C.B., Trinkaus, E. and Holliday, T.W. 1997. Body mass and encephalization in Pleistocene Homo. *Nature*, 387, 173–6.

Ruff, C., Holt, B, and Trinkaus, E. 2006a. Who's afraid of the big bad Wolff? "Wolff's law" and bone functional adaptation. *American Journal of Physical Anthropology*, 129, 484–98.

Ruff, C.B., Holt, B.M., Sladek, V., Berner, M., Murphy, Jr. W.A., zur Nedden, D., Seidler, H. and Recheis, W. 2006b. Body size, body proportions, and mobility in the Tyrolean 'Iceman'. *Journal of Human Evolution*, 51, 91–101.

Rybicki, E.F., Simonen, F.A. and Weis, Jr. E.B. 1972. On the mathematical analysis of stress in the human femur. *Journal of Biomechanics*, 5, 203–15.

Schoenau, E., and Frost, H. 2002. The 'muscle-bone unit' in children and adolescents. *Calcified Tissue International*, 70, 405–7.

Shackelford, L.L. 2007. Regional variation in the postcranial robusticity of late Upper Paleolithic humans. *American Journal of Physical Anthropology*, 133, 655–68.

Shaw, C.N. and Ryan, T.M. 2011. 'More than the midshaft?' Mapping cross-sectional properties along the entire femoral and tibial diaphysis. *American Journal of Physical Anthropology Supplement*, 144(S52), 272.

Shaw, C.N. and Stock, J.T. 2013. Extreme mobility in the Late Pleistocene? Comparing limb biomechanics among fossil Homo, varsity athletes and Holocene foragers. *Journal of Human Evolution*, 64(4), 242–9.

Shaw, C.N. and Stock, J.T. 2009a. Habitual throwing and swimming correspond with upper limb diaphyseal strength and shape in modern human athletes. *American Journal of Physical Anthropology*, 140(1), 160–72.

Shaw, C.N. and Stock, J.T. 2009b. Intensity, repetitiveness, and directionality of habitual adolescent mobility patterns influence the tibial diaphysis morphology of athletes. *American Journal of Physical Anthropology*, 140(1), 149–59.

Sladek, V., Berner, M. and Sailer, R. 2006a. Mobility in Central European Late Eneolithic and Early Bronze Age: Tibial cross-sectional geometry. *Journal of Archaeological Science*, 33, 470–82.

Sladek, V., Berner, M. and Sailer, R. 2006b. Mobility in Central European Late Eneolithic and Early Bronze Age: Femoral cross-sectional geometry. *American Journal of Physical Anthropology*, 130, 320–32.

Sparacello, V. and Marchi, D. 2008. Mobility and subsistence economy: A diachronic comparison between two groups settled in the same geographical area (Liguria, Italy). *American Journal of Physical Anthropology*, 136, 485–95.

Sparacello, V. and Pearson, O.M. 2010. The importance of accounting for the area of the medullary cavity in cross-sectional geometry: A test based on the femoral midshaft. *American Journal of Physical Anthropology*, 143(4), 612–24.

Starling, A.P. and Stock, J.T. 2007. Dental indicators of health and stress in early Egyptian and Nubian agriculturalists: A difficult transition and gradual recovery. *American Journal of Physical Anthropology*, 134, 520–8.

Steinberg, M.E. and Trueta, J. 1981. Effects of activity on bone growth and development of the rat. *Clinical Orthopaedics and Related Research*, 156, 52–60.

Stock, J.T. 2006. Hunter-gatherer postcranial robusticity relative to patterns of mobility, climatic adaptation, and selection for tissue economy. *American Journal of Physical Anthropology*, 131, 194–204.

Stock, J.T. 2009. Ecogeographic variation in the ontogeny of hunter-gatherer physique and skeletal robusticity [Abstract]. *American Journal of Physical Anthropology Supplement*, 138(S48), 248.

Stock, J.T. and Pfeiffer, S. 2001. Linking structural variability in long bone diaphyses to habitual behaviors: Foragers from the southern African

Later Stone Age and the Andaman Islands. *American Journal of Physical Anthropology*, 115, 337–48.

Stock, J.T. and Pfeiffer, S. 2004. Long bone robusticity and subsistence behaviour among Later Stone Age foragers of the forest and fynbos biomes of South Africa. *Journal of Archaeological Science*, 31, 999–1013.

Stock, J.T. and Shaw, C.N. 2007. Which measures of diaphyseal robusticity are robust? A comparison of external methods of quantifying the strength of long bone diaphyses to cross-sectional geometric properties. *American Journal of Physical Anthropology*, 134, 412–23.

Stock, J.T., O'Neill, M.C., Ruff, C.B., Zabecki, M., Shackelford, L.L. and Rose, J. 2011. Body size, skeletal biomechanics, mobility and habitual activity from the Late Palaeolithic to the Mid-Dynastic Nile Valley, in *Human Bioarchaeology of the Transition to Agriculture*, edited by R. Pinhasi and J.T. Stock. Chichester: Wiley-Blackwell, 347–67.

Sumner, D.R., Mockbee, B. and Morse, K. 1985. Computed tomography and automated image analysis of prehistoric femora. *American Journal of Physical Anthropology*, 68, 225–32.

Szulc, P., Seeman, E., Duboeuf, F., Sornay-Rendu, E. and Delmas, P. 2006. Bone fragility: Failure of periosteal apposition to compensate for increased endocortical resorption in postmenopausal women. *Journal of Bone and Mineral Research*, 21, 1856–63.

Trinkaus, E. and Ruff, C.B. 1989. Diaphyseal cross-sectional morphology and biomechanics of the Fond-de-Foret 1 femur and the Spy 2 femur and tibia. *Bulletin de la Société Royale Belge d'Anthropologie et de Préhistoire*, 100, 33–42.

Trinkaus, E. and Ruff, C.B. 2012. Femoral and tibial diaphyseal cross-sectional geometry in Pleistocene Homo. *PaleoAnthropology*, 2012, 13–62.

Trinkaus, E., Churchill, S.E. and Ruff, C.B. 1994. Postcranial robusticity in Homo. II: Humeral bilateral asymmetry and bone plasticity. *American Journal of Physical Anthropology*, 93, 1–34.

Villotte, S., Churchill, S.E., Dutour, O.J. and Henry-Gambier, D. 2010. Subsistence activities and the sexual division of labor in the European Upper Paleolithic and Mesolithic: Evidence from upper limb enthesopathies. *Journal of Human Evolution*, 59, 35–43.

Volkman, S.K., Galecki, A.T., Burke, D.T., Paczas, M.R., Moalli, M.R., Miller, R.A. and Goldstein, S.A. 2003. Quantitative trait loci for femoral size and shape in a genetically heterogeneous mouse population. *Journal of Bone and Mineral Research*, 18(8), 1497–1505.

Volkman, S.K., Galecki, A.T., Burke, D.T., Miller, R.A. and Goldstein, S.A. 2004. Quantitative trait loci that modulate femoral mechanical properties in a genetically heterogeneous mouse population. *Journal of Bone and Mineral Research*, 19(9), 1497–1505.

Wallace, I.J., Middleton, K.M., Lublinsky, S., Kelly, S.A., Judex, S., Garland Jr., T. and Demes, B. 2010. Functional significance of genetic variation

underlying limb bone diaphyseal structure. *American Journal of Physical Anthropology*, 143, 21–30.

Weaver, T.D. 2002. *A Multi-Causal Functional Analysis of Hominid Hip Morphology*. Unpublished PhD Dissertation, Stanford University.

Wells, J.C.K. and Stock, J.T. 2007. The Biology of the Colonizing Ape. *Yearbook of Physical Anthropology*, 50, 191–222.

Wergedal, J., Sheng, M., Ackert-Bicknell, C., Beamer, W.G. and Baylink, D.J. 2005. Genetic variation in femur extrinsic strength in 29 different inbred strains of mice is dependent on variations in femur cross-sectional geometry and bone density. *Bone* 36, 111–22.

Wolff, J. 1892. *Das Gesetz der Transformation der Knochen*. Berlen: Quarto.

Zakrzewski, S.R. 2003. Variation in Ancient Egyptian stature and body proportions. *American Journal of Physical Anthropology*, 121, 219–29.

Zakrzewski, S.R. 2007. Population continuity or population change: Formation of the Ancient Egyptian state. *American Journal of Physical Anthropology*, 132, 501–9.

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Chapter 8

Women on the Move. The DNA Evidence for Female Mobility and Exogamy in Prehistory

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Introduction

Male mobility has been cited as a factor in the spread of prehistoric technology and material culture in Bronze Age Europe (Kristiansen and Larsson 2005). The heroic travels of smiths, traders, warriors and seafarers has been seen as instrumental in the transmission of knowledge and the formation of connections between elite groups in different parts of the Old World (Della Casa 2011). The Amesbury Archer burial found in the vicinity of Stonehenge has been interpreted as an heroic traveller, a member of an elite, an especially mobile male, thanks to strontium isotopic evidence indicating a childhood spent in the Alpine region of Europe (Fitzpatrick 2011).

Scientific evidence for female mobility also exists in the form of strontium isotope analysis which has shown that individual women moved locations during their life time, mainly but not always as a result of exogamy (Bentley 2013, Bentley et al. 2012). However there seems to be little evidence of this movement in the material culture record and one wonders why this is the case. Are the traces left by women so ephemeral in the archaeological record or is the reason that archaeologists have simply not considered the mobility of women as an explanation for material culture change, and the transmission of technology and knowledge? The answer is that female mobility has up till now been an under researched area compared to that of male mobility, maybe it is perceived as being a less important factor in its implications for influencing material culture. There is a lack of theory that considers female mobility and action in prehistory – agency and phenomenology are largely masculine concepts (see Hamilton et al. 2006 for a critique of the 'maleness' of phenomenology). Questions that should to be asked include what types of motivation could be urging women to migrate – are they different from men's motives? Does biological sex, for instance childbirth and childcare, make it more difficult to travel longer distances? Did past cultures 'disapprove' female movement and thus prevent it? Do our perceptions of sedentary farming communities colour our assumptions about female mobility when we accept it is a given in gatherer-hunter societies? We should also distinguish between different types of female mobility – population movement, seasonal mobility and once in a lifetime movement, exogamy. Exogamy is hugely

important as a way of creating alliances between groups and reducing conflict. We might consider the wearers of Wessex type amber necklaces and composite necklaces in the Bronze Age as elite women who married into other elite groups in order to create alliances and elite women may have moved over long distances to join other elite groups.

This chapter aims to redress the balance by shifting the focus away from male activities and mobility and the interpretive bias that assumes technology and knowledge transfers are only mediated by men. To do this I present evidence that there was substantial exogamous movement of women in the Neolithic of Europe. The evidence I wish to consider is DNA, both from present day populations and past populations. Evolutionary geneticists have used mitochondrial (mt) DNA to study human populations around the world since the molecule was first completely sequenced in 1981 (Anderson et al. 1981). Over a decade later the Y chromosome began to be used in the same way. As I will explain, mt DNA tells the female side of the human story while the Y chromosome gives us the male version. Mt DNA was used to show that the evolution of *Homo sapiens* took place in Africa and how modern humans then left Africa and colonised the rest of the world. Both mt DNA and Y chromosome studies can throw light on female mobility in prehistory.

Mitochondrial DNA

Mitochondrial DNA is found in the mitochondria (s. mitochondrion) which are small organelles found in the cytoplasm of cells. Each cell may have hundreds of mitochondria, and each mitochondrion has about ten copies of the small mitochondrial DNA molecule. There are thought to be about 8000 identical copies of mt DNA molecules in each cell. Mitochondria are believed to have originated as independent organisms that entered into a symbiosis with more complex cells 1.5 billion years ago. They have lost most of their genes to the nuclear DNA (the DNA that is packaged into chromosomes in the cell nucleus) but the 37 genes they still retain are involved in the production of energy. Mt DNA is inherited maternally – it is not transmitted by males to the next generation (although there have been some controversial papers published suggesting that this can happen in non-humans – if it does happen in humans it is so rare that it has no impact on population studies). Mt DNA does not undergo recombination with the nuclear DNA so any mutations (changes in the DNA sequence) acquired in the past are maintained through the generations. Two non-coding regions (i.e. they do not contain functional genes) of mt DNA are studied as these seem to accumulate point mutations (a change at an individual position in the DNA sequence) at a high rate – the hypervariable regions I and II (HVRI and HVRII). These mutations are inherited together and form a set of DNA markers that have been classified into haplotypes by comparison to a standard mt DNA sequence called the Cambridge Reference Sequence (CRS) (see endnote). A number of similar haplotypes form a haplogroup. By assuming that

mutations are acquired at a regular rate, the concept of a 'molecular clock' can be applied and the time of appearance of new mt DNA haplogroups can be estimated (also known as divergence or coalescence times) although this dating method has wide confidence limits.

Mt DNA from human populations around the world has been classified into approximately 90 haplogroups, and these haplogroups have shed light on the evolution of modern humans in Africa, and the movements of these people out of Africa into Asia, Europe and America. Without going into details here of the particular mutations that are found in each haplogroup (interested readers can find this information in human genetics textbooks), it can be noted that mt DNA haplogroups are named after letters of the alphabet in a somewhat arbitrary way. Most modern European mt DNA lineages belong to the following haplogroups: H, V, U, K, J and T – which in turn derive from haplogroup R. Other European mt DNA haplogroups are I, W and X which derive from haplogroup N, also found in Europe. Haplogroups are further divided into subgroups or subclades, such as U5, which is a subclade of U and seems to be specific to Europe, although other subclades of European haplogroups are also found in the Near East and Africa. Subclades have generally emerged later than the haplogroup itself. A haplogroup with a letter and an asterisk denotes all sequences belonging to that haplogroup that are not already defined as belonging to a subclade – one such example is the N* haplogroup found at two Spanish Neolithic sites (Gamba et al. 2012 – discussed below). The genetic outcome of the continuous movement of women over generations can be seen in the distribution of mt DNA haplogroups in Europe. This means that mt DNA haplogroups cannot be identified to populations (Barbujani et al. 1998) or to cultures.

Y chromosome DNA

This is the smallest human chromosome and confers maleness in mammals (usually – there are exceptions to every rule in biology). It is inherited paternally, from father to son. Unlike the mt DNA, the Y chromosome does undergo recombination and pairs with the X chromosome at the tips of the chromosomes during meiosis. This means that there is an internal region of the Y chromosome which remains unaffected by recombination, called the NYR (non-recombining region of the Y chromosome which forms 95 per cent of the chromosome). This region of the Y chromosome contains the SRY gene which determines maleness, but it also contains a set of DNA markers which can be inherited as a block, that is, a haplotype. Analysis and classification of the Y chromosome into haplogroups started a decade later than the mt DNA work. The Y chromosome markers include point mutations similar to those found in mt DNA, as well as more complex variations such as indels (insertions or deletions of short pieces of DNA) and STRs (Short Tandem Repeats – repeated short DNA motifs a few nucleotides long) and the application of the molecular clock concept to date the

emergence of new Y haplogroups is less straightforward than for the mt DNA. Y chromosome haplogroups are also named after letters and subdivided in the same way as mt DNA haplogroups. There are 20 defined Y haplogroups based on point mutations and indels, numbered from A to T, while haplotypes are defined by additional information from STRs. European Y chromosome haplogroups include E, F, I/J, K, H, G and N, while Y haplogroup R, one of the most common in modern European populations, may have originated in southern or southwestern Asia.

In some societies, women move more than men!

A pivotal paper published in 1998 by Seielstadt et al. analysed mt DNA and Y chromosomal DNA from 14 African populations and came to the surprising conclusion that males travelled less than females. They found that Y chromosome variants tended to be more localised geographically than mt DNA and the autosomes (the rest of the chromosomes). They suggested that patrilocal exogamy was the social mechanism that accounted for the difference in migration rates between males and females. In fact the migration rate for females was estimated to be *eight* times higher than for males. In patrilocal exogamy the males stay where they were born but the females move from their birthplace to another location at marriage. Patrilocality is often associated with patrilineal inheritance, with sons inheriting land from their fathers. They would also inherit the same Y chromosome – this has important implications when we come to consider the genetic outcomes and signatures of patrilocal exogamy.

It is true that in some societies men do indeed move more than women – it is however the intergenerational, continual movement of women in exogamous marriages that accounts for the genetic outcomes seen in Seielstadt et al. (1998). This does not mean that every woman in a community would necessarily change community upon marriage, but a significant number over the generations would. Data on patrilocal exogamous marriages collected from Australian Aborigines in the 1950s (shortly after first contact with white Europeans) showed that intertribal marriages consisted of 12.33 per cent of all marriages (data cited in Lasker and Crews 1996). In other words, in an average tribe of 500 people, 62–3 individuals would be the offspring of a woman from a different tribe, and 7–8 individuals would have a mother from a distant tribe. So over 10 per cent of a tribe could consist of individuals with kin in other tribes, and if their mothers are also included, maybe as much as 20 per cent.

Predicted genetic outcomes of patrilocal exogamy

If patrilocal exogamy is common in a population then we can make three predictions:

1. Because of the associated patrilineality, we would expect to see a reduction in Y chromosomal diversity, i.e. the number of Y chromosome haplogroups present in a population would decrease over time, and the frequency of those remaining Y haplogroups would be higher than expected.
2. We would also expect to see a high mt DNA diversity compared to the Y chromosome, because the movement of women into the population via exogamy would introduce new haplotypes not previously present in the receiving population.
3. We might also expect to see mt DNA haplogroups change in number and/or frequency every two generations. This happens because the sons of the women who moved into a population remain in that population, whereas their daughters would move to other groups in exogamous marriages. Then the sons would marry wives from other groups in exogamous marriages, and these wives would sometimes bring new mt DNA haplogroups into the population, but the Y chromosome haplogroups would not change. However to see this happening at an archaeological site with ancient DNA would require very close dating of human remains to within generation times (Dudar et al. 2003).

Armed with these predictions, can we distinguish between these genetic outcomes in different kinds of society, i.e. exogamy versus endogamy, matrilocality versus patrilocality? Understanding how human social structures affect population genetics is of great importance to evolutionary geneticists trying to understand genetic data collected from populations around the world in order to reconstruct human population histories and human evolution. So there is genetic research carried out on present-day traditional societies to understand how these social structures affect genetic outcomes.

Social structures and genetic structure in Central Asia

Before attempting this analysis with ancient DNA data from archaeological material, we should consider the outcomes of a similar study with model modern populations. A genetic survey was carried out on traditional pastoral and farming populations in Central Asia in order to assess how the various types of social structure found in these populations affected genetic diversity in the mt DNA and Y chromosome haplogroups (Chaix et al. 2007). The populations sampled for DNA included Karakalpaks, Kazakhs, Kyrgyzs, Uzbeks and others – in all mt DNA was sampled from 12 pastoral societies and nine farming societies, while Y chromosomes were analysed from 11 pastoral societies and seven farming societies. The social organisation and marriage patterns were known for each society.

As predicted above, reduced Y chromosomal diversity was found in pastoral societies with exogamous marriages but mt DNA diversity was unaffected. This reduced Y chromosome diversity was the result of a patrilineal clan system where

the man must chose a bride from a different clan or lineage. 'Identity core' Y chromosomes were present – these are Y chromosome haplogroups that are present at high frequencies and are the result of patrilineal descent and little migration amongst men. It can be said that a clan is made up of an identity core Y chromosome with a few other haplotypes (variations caused by a mutation of the haplogroup) present at very low frequencies. In contrast the farming societies showed no reduction in Y chromosome diversity with very few core identity Y chromosome haplogroups seen. However farmers are organised into extended or nuclear families and often practice endogamous marriages with cousins. The observed mt DNA diversity is still high in the farmers. The similarity of the level of mt DNA diversity in both the pastoralists and the farmer societies contradicts the expectation of lower mt DNA diversity for societies with endogamous, especially cousin, marriages. This needs some explanation. A population can be modelled as the SLOSS (Single Large Or Several Small) model, where we can compare a single large panmictic (genetically mixing) population to a population of the same size which is subdivided into several smaller isolated groups. In this model it is predicted that each subgroup of the SS population will quickly fix a different allele (genetic variant). On a short-term basis therefore high diversity will be seen in the SS population as a whole, but over time, as some subgroups die out, there will be a reduction of diversity. The pastoral Y chromosomes fit this scenario, while the exogamous marriages maintaining a high diversity for the mt DNA fit the SL population model. It appears that the Uzbeks were pastoralists who adopted farming relatively recently in the sixteenth century AD and changed their traditional way of life by practising endogamy and other social customs from farmers. The lack of difference in the mt DNA diversity in endogamous marriage patterns and exogamous marriages is also seen in some Indian matrilocal societies (Kumar et al. 2006) and is explained by the SL model. This is because although the marriages in these societies are classed as endogamous, in reality the marriages involve distant cousins as well as close ones. These distant cousins may well bring different mt DNA haplogroups into the society into which they move. In other words, endogamous marriages may in their genetic effect be similar to exogamous marriages. In highly endogamous Indian societies with strict rules there is some reduction of mt DNA diversity in that the number of haplotypes is reduced.

Broadly speaking, in societies that practise patrilocal exogamy the predictions above hold good and we can use these to examine ancient human DNA.

Patrilocal exogamy has deep roots

It is sometimes suggested that patrilocal exogamy became established only with the introduction of agriculture and that farming changed social structures and marriage patterns (Wilkins and Marlowe 2006). However, a phylogenetic study of mt DNA from contemporary gatherer-hunter groups by Walker et al. (2011) shows that there is a deep evolutionary history of arranged marriages or regulated

mate exchange in gatherer-hunter groups that goes back in prehistory to the first modern human migrations out of Africa. They propose that there were low levels of polygyny and that reciprocal exchanges between kin groups involved bride price and/or bride service (kin exogamy). These mate exchanges may require movement of males (in bride service to the kin group) as well as females but are more likely to affect females. But contemporary gatherer-hunter groups may not be directly descended in an unbroken line from our African ancestors, and traditions can change over time. What other evidence is there for the deep roots of exogamous marriage practices?

Direct genetic evidence for the antiquity of patrilocal exogamy in gatherer-hunters has been obtained in an ancient DNA analysis of a Neanderthal group found in El Sidrón cave, Asturias, Spain (Lalueza-Fox et al. 2011). Dating to *c*.49,000 years ago, a single catastrophic event appears to have killed a group of at least 12 Neanderthal individuals, consisting of six adults, three adolescents, two juveniles and one infant. The six adults comprised three males and three females identified from osteoarchaeology. Two of the adolescents were probably also male, while the sex of the other adolescent and the two juveniles and infant could not be identified. The mt DNA was extracted and analysed from these individuals and a Y chromosome test was used only to confirm the sex identifications of the males, not to obtain Y chromosome haplogroups. The mt DNA haplogroups belonged to three lineages already shown to exist in the El Sidrón individuals in a previous study. These three haplogroups are called A, B and C. Most of the El Sidrón people belonged to either haplogroup A (7) or C (4). Only one individual carried haplogroup B; a female adult. In fact each adult female had a different mt DNA haplogroup, whereas the three adult males all belonged to mt DNA haplogroup A, implying that they were maternally related, probably brothers. Two of the adolescents belonged to haplogroup A and the third to haplogroup C, while one juvenile belonged to C and the other juvenile and the infant belonged to haplogroup A. The authors of this study suggest that these results are explained by patrilocality amongst Neanderthal males, resulting in a greater diversity of mt DNA haplogroups seen in females compared to males. In this case as few as three mt DNA haplogroups would seem to suggest patrilocal exogamy.

Is there ancient DNA evidence for patrilocal exogamy?

Much of ancient DNA research is concerned with examining the genetics of the Mesolithic-Neolithic transition in Europe and whether there was a demic expansion from the Near East that contributed to the spread of agriculture. These studies can be criticised on general grounds in that there are too few ancient DNA sequences as yet to undertake the kind of population studies that are seen with modern DNA where hundreds, if not thousands, of DNA samples from individuals are sequenced and statistically analysed. Nevertheless the ancient DNA studies cited here have all been presented as population studies either focusing on the

spread of agriculture or the transition from gatherer-hunters to farmers in Europe. But armed with our genetic predictions for patrilocal exogamy described above, I can look at the ancient DNA results obtained from Neolithic sites and ask whether this genetic signature was present in these communities. Ancient DNA is fragmented, chemically damaged and survives in minute (picogram) amounts in human remains, and many external factors such as temperature and soil pH can affect its survival. There is never a 100 per cent success rate of recovery of ancient DNA from human remains, although the success rate can be greatly improved if ancient DNA analysis can be carried out as soon as possible after the human remains are excavated (Pruvost et al. 2007).

As already described above, mt DNA is the preferred and sometimes only ancient DNA target available for PCR amplification as it has a very high copy number with thousands of molecules present in each cell. In contrast the Y chromosome has a very low copy number, with only one copy per cell, so is less likely to survive as ancient DNA. It may therefore not always be possible to see the reduced Y chromosome diversity that is the signature for patrilineality and patrilocality, but the mt DNA diversity should be enough to at least indicate the movement of women, most likely through exogamy. Ideally ancient DNA analysis should be carried out with Strontium and Oxygen isotope analysis in order to give a full picture of the movement of both sexes, but so far very few sites have had both kinds of analyses carried out on their human remains.

Ancient DNA analysis has been carried out on Neolithic sites in France, Spain and Germany – however no similar studies have yet been undertaken in Britain. Two Neolithic sites in France have yielded ancient DNA evidence detailed in recently published articles (Deguilloux et al. 2011, Lacan et al. 2011). Both articles purport to examine the spread of the Neolithic across Europe through palaeogenetic evidence which can be interpreted as supporting the hypothesis of a demic expansion, although as Deguilloux et al. (2011) point out, because of limited Neolithic ancient DNA data, other scenarios, including long-distance marriage exchanges are equally likely.

Péré tumulus C is a megalithic long mound 100 m in length constructed between 4500–4000 BC located at Prissé-La-Charrierrè in west-central France. The mound contained three burial chambers and human remains in chamber III were analysed for ancient DNA (Deguilloux et al. 2011). At least eight individuals, including four adults and four children, were identified from the disarticulated skeletal remains and of these six well-preserved individuals were sampled for DNA, comprising three adults and three children. Mitochondrial DNA sequences were obtained from one adult and two children.

When assigned to mt DNA haplogroups the adult belonged to X2, the older child (12 years old) belonged to U5b and the younger child (six years ± 24 months) belonged to N1a. It can be justly pointed out that three results are not enough to make conclusions about Neolithic populations in Western France, or the demographic processes involved in the spread of the Neolithic in this region; however the individual mt DNA haplogroups found here are of interest in their

own right. Haplogroup X2 has been previously found in a Late Neolithic family burial group at Eulau, Germany (Haak et al. 2008), and is found at low frequencies in the modern European population. The specific mt DNA sub-haplogroup U5b (characterised by a mutation at nucleotide position 16271) has apparently not been found in France before and does not seem to occur in the modern French population according to Deguilloux et al. (2011). It has been found, again in Germany, at the site of Eulau (Haak et al. 2008) and in gatherer-hunters analysed by Bramanti et al. (2009) and has been interpreted as a 'signature' haplogroup of pre-Neolithic European populations. The final mt DNA haplogroup identified at Prissé-La-Charrierè was N1a, which occurs at very low frequencies in modern European populations (0.14 per cent in Europe and 0.27 per cent in France: Deguilloux et al. 2011) but once again has been found in six individuals at German Neolithic sites of the Linearbandkeramik culture (Haak et al. 2005). The specific individual haplotype N1a found at Prissé-La-Charrierè has been found at Ecsegfalva in Hungary, an AVK site dating to 6000 BC (Haak et al. 2005). The N1a mt DNA haplogroup had been proposed by Haak et al. (2005) as a 'signature' haplogroup of the LBK but this notion has been disproved with the discovery of N1a at Prissé-La-Charrierè in west-central France.

What we can say about the presence of three very different mt DNA haplogroups is that they show a certain amount of mt DNA diversity that could be consistent with the practice of patrilocal exogamy. No Y chromosomal DNA was obtained from Prissé-La-Charrierè due to the relatively poor preservation of ancient DNA in the human remains, so it is not possible to see any corresponding reduction in Y haplogroup diversity.

The second French Neolithic site is Cave I at Treilles, Avreyon, in southeast France (Lacan et al. 2011). Dating to *c*.3000 BC towards the end of the Neolithic period, this cave was used as a necropolis. The remains of a minimum of 149 individuals buried over 100 to 200 years are represented in the assemblage of disarticulated and fragmented bones recovered from the cave. As such this represents a good population sample which included 86 adults and 63 children and subadults. In order to sample individuals once, teeth from mandibles were used to take samples for ancient DNA analysis. Ancient DNA was extracted from the teeth from 53 individuals; however only 29 individuals had sufficiently preserved DNA for mt DNA haplotypes to be obtained. More encouragingly Y chromosomal haplotypes could be obtained from 22 individuals. These results indicate good ancient DNA preservation with an over 50 per cent success rate. Sex identification of these individuals indicates that 22 males and two females were present according to DNA methods; osteological methods based on well-preserved pelves indicated 20 males and ten females. These results show a sex ratio imbalance with males greatly dominating the burial assemblage, which suggests that male lineages dominated in burial rituals. This is reinforced when one looks at the Y chromosome diversity seen in the ancient DNA results. Only two Y chromosome haplogroups were present – 20 males belonged to the G2a Y haplogroup while only two males belong to I2a. This represents a very low genetic diversity for

Y chromosome haplogroups. Moreover the authors of this study show that these haplotypes are rare in modern European populations – the highest frequencies of these Y chromosome haplogroups are found in Mediterranean populations, but at very low percentages, 0.35–2.0 per cent In contrast the mt DNA results show 13 different mt DNA haplotypes which belong to 11 mt DNA haplogroups.

Over 50 per cent of the mt DNA haplogroups identified belong to Upper Palaeolithic mt DNA lineages that have been present in Europe since the colonisation of Europe *c*.50,000 years ago. These lineages include U, U5, HV0, X2, K1a and T2b, while 28 per cent of the mt DNA lineages originated after the last glacial maximum, including H1, H3, V and U5b1c. Another 20 per cent of the lineages (from six samples) belonged to J1 haplogroup – this haplogroup is usually associated with a demic contribution from the Near East into Europe with the introduction of agriculture. The six J1 haplotypes also show a lack of diversity within their sequences, indicating a recent origin, while the greater diversity seen with the U5 haplotype sequences at Treilles corresponds to the greater antiquity of this haplogroup. As described above, U5 (and other U haplogroups) have been suggested to derive from the original gatherer-hunter Palaeolithic population of Europe (Bramanti et al. 2009). However we are dealing with a site dating to 3000 BC and any gatherer-hunter populations would have been assimilated into agricultural populations by this stage. It should also be noted that the N1a mt DNA haplogroup was not identified at Treilles.

The ancient DNA results from Cave I at Treilles fit very well with the genetic outcomes predicted for patrilocal exogamy, with a very low Y chromosome haplogroup diversity and a high mt DNA haplogroup diversity – indeed Lacan et al. (2011) has been cited by Bentley et al. (2012) as genetic evidence for a Neolithic patrilocal kinship system supporting the findings of strontium isotope analysis at LBK sites. Thanks to the cool, constant internal temperature of the Cave I at Treilles, ancient DNA has been well preserved so that it was possible to obtain the normally elusive low copy Y chromosome DNA. It is this information from the Y chromosome that is so often lacking in ancient DNA studies, but at this site has confirmed the social practice of patrilocal exogamy.

Three Neolithic sites from north eastern Spain have recently been analysed for ancient DNA in order to shed light on the Neolithisation of the peninsula (Gamba et al. 2012). Once again these ancient DNA results can be used to examine whether the social practice of patrilocal exogamy was taking place. Two of the sites were caves – the third was an open-air site. As might be suspected these environments differentially affect the preservation of ancient DNA in human remains, with more ancient DNA being obtained from the cave sites compared to the open-air site.

The earliest dated site is Can Sadurní cave, 5475–5305 cal BC, where seven individuals were sampled for DNA from teeth. Another Early Neolithic cave site, Chaves, dated to 5329–4999 BC, supplied DNA samples from three individuals, both bone and teeth samples. The third site was Sant Pau del Camp, a late early Neolithic open-air site, where 12 individuals were sampled for ancient DNA. Of this total of 22 individuals, 13 ancient mt DNA sequences were obtained, as

success rate of 59 per cent. No Y chromosome DNA was recovered. The nine mt DNA haplotypes identified belonged to 5 haplogroups – N*, K, H, U5 and X1. Five different haplotypes were found in the Can Sadurní cave – these were N* (3), K(1), H (1), U5 (1) and X1 (1). At Chaves two haplotypes were identified – K(1) and H(2). At Sant Pau del Camp three different haplotypes were present – K(1), H20 (1) and N*(1). When we look at the mt DNA haplogroups found at these three Neolithic sites there are some interesting features to note. Haplogroup H is the most frequent haplogroup in modern European populations; estimates vary between 46 per cent to over 50 per cent. Haplogroup K is rarer, about 4–6 per cent of the modern European population belong to this haplogroup. Its most famous member is Otzi, the Tyrolean Iceman. U5 has been discussed above – it is thought to be associated with the first colonisers of Europe *c*.50,000 years ago, and is present in *c*.9 per cent of the modern European population. Haplogroup N* is extremely rare and the authors could not find it in a search of DNA databases for modern European populations. Haplogroup X is also rare – being found at 2–3 per cent frequency in modern Europeans, native Americans, Near Easterners and North Africans. The X1 subclade of haplogroup X that was found at Can Sadurní is extremely rare today being found in the Near East and Northern and Eastern African modern populations. Haplogroups that are rare today may have been more frequent in the past and they can become lost from populations due to genetic drift. It is very interesting to see now rare haplogroups appearing in ancient populations.

It is difficult to say whether this mt DNA haplotype diversity conforms to the predicted genetic outcome for patrilocal exogamy as the sample numbers are on the small size (this did not stop the authors from carrying out various population genetic analyses!). But the mt DNA diversity seen at Can Sadurní, where seven individuals were buried and five different haplotypes belonging to five different haplogroups were identified by Gamba et al. (2012), indicates a high diversity and the presence of multiple mt DNA lineages even in this small population sample and could possibly be interpreted as the result of the movement of women in exogamy.

The Linearbandkeramik (LBK) culture in Germany and Central Europe (5500–4900 cal BC) is perhaps the most intensively studied archaeological population, in terms of excavation, theory and science. The science has concentrated on the movement of individuals with strontium isotope analysis (Bentley 2013, Bentley et al. 2012) while ancient DNA analysis has been used to identify the population affinities of these Early Neolithic farming pioneers (Haak et al. 2010) and to suggest that there was little genetic continuity between the indigenous gatherer-hunter populations and the incoming LBK farmers (Bramanti et al. 2009). However, strontium isotope analysis has shown that there was movement of individuals from the gatherer-hunter groups into farming settlements, and that many of these individuals were female. This has been interpreted as evidence for a social system of patrilocal exogamy and the archaeological evidence from Talheim strikingly supports this in addition to the isotopic evidence. At Talheim (4900–4800 cal BC) the burial evidence consisted of nine adult males, four adult

females, two adults of unknown sex and 16 children buried together in a single pit – but young females were missing from this small population. The four adult women were shown to be non-locals by strontium isotopic analysis. The burials resulted from a violent attack in which it seems the young females were captured by the attackers. It has also been suggested that skeletal non-metric traits show the presence amongst the burials of a nuclear family (Bentley 2013). Although no ancient DNA analysis was carried out on these burials it is accepted that patrilocal exogamy was practised by the LBK communities.

A few LBK sites have had *both* strontium isotope analyses *and* ancient DNA analyses carried out on the individuals, for example Flomborn, Schwetzingen and Vaihingen, although it is not clear from published papers whether the same individuals were used in both types of analyses. So the question is – where Strontium isotope evidence is absent, do the ancient DNA sequences available for LBK sites also support patrilocal exogamy?

A total of 42 ancient mt DNA sequences have now been published from LBK sites, with 22 sequences coming from one site alone, Derenburg, and 20 sequences from nine other sites. Derenburg has also yielded three Y chromosome sequences. Population genetic analyses have been carried out by Haak et al. (2005), Bramanti et al. (2009) and Haak et al. (2010), but this is still a very small number of sequences to analyse and make conclusions about the LBK population. One claim that has been overturned is that the mt DNA haplogroup N1a was a 'signature' haplogroup of the LBK found in no other population (Haak et al. 2005) – however this mt DNA haplogroup has now also been found in west-central France (Deguilloux et al. 2011).

The mt DNA haplogroups found at LBK sites are listed in Table 8.1. All sites are in Germany unless otherwise stated. They include Asparn Schletz, Austria, H* (1), Eilsleben, H* (1), Flomborn, N1a (1), H* (1), T (1), K (2), Halberstadt, V (1), T (1), N1a (1), Schwetzingen, T (3), H* (1), Seehausen, J* (1), Unterwiederstedt, K(1), N1a (1), Vaihingen, U3 (1), Ecsegfalva, Hungary, N1a(1). At some sites it can be seen that several mt DNA haplogroups are present, for example four at Flomborn and three at Halberstadt. From this DNA evidence it would be hard to discern patrilocal exogamy, but fortunately this is well attested by the Strontium isotope evidence at other sites. There are no surprises in the mt DNA haplogroups that are present at LBK sites – all are of European provenance but with affinities to Near Eastern populations (Haak et al. 2010).

Table 8.1 List of Neolithic sites, with dates, mt DNA haplogroups and Y haplogroups present

Site	Date	MtDNA haplogroups	Y haplogroups
Péré tumulus C, France	4500–4000 BC	U5b (1), N1a (1), X2 (1)	None
Cave I at Treilles, France	*c*.3000 BC	J1 (6), U5 (6), X2 (4), H1 (3), H3 (3), HV0 (2), K1a (2), T2b (2), H (1), N1* (1), U (1), U5b1c (1), V (1)	G2a (20), I2a (2)
Can Sadurní cave, Spain	5475–5305 BC	N* (3), H (1), K (1), U5 (1), X1 (1)	None
Chaves, Spain	5329–4999 BC	H (2), K (1)	None
Sant Pau del Camp, Spain	4250–3700 BC	H20 (1), K (1), N* (1)	None
Asparn Schletz, Austria	LBK	H* (1)	None
Eilsleben, Germany	LBK	H* (1)	None
Flomborn, Germany	LBK	H* (1), K (2), N1a (1), T (1)	None
Halberstadt, Germany	LBK	N1a (1), T (1), V (1)	None
Schwetzingen, Germany	LBK	H* (1), T (3)	None
Seehausen, Germany	LBK	J* (1)	None
Unterwiederstedt, Germany	LBK	K(1), N1a (1)	None
Vaihingen, Germany	LBK	U3 (1)	None
Ecsegfalva, Hungary	LBK	N1a(1)	None
Derenburg-Meerenstieg II, Germany	5200–4900 BC	HV (3), J (3), K (3), N1a (3), T2 (3), H (2), W (2), T (1), U5a1a (1), V (1)	F* (2), G2a3 (1)
Eulau, Germany	2600 BC	K1b (3), X2 (2), H (1), I (1), K1a2 (1), U5b(1), J (1?), N (1?)	None
Ostorf, Germany	3200–2950 BC	T2e (2), U5 (2), K(1), J (1), U5a (1)	None

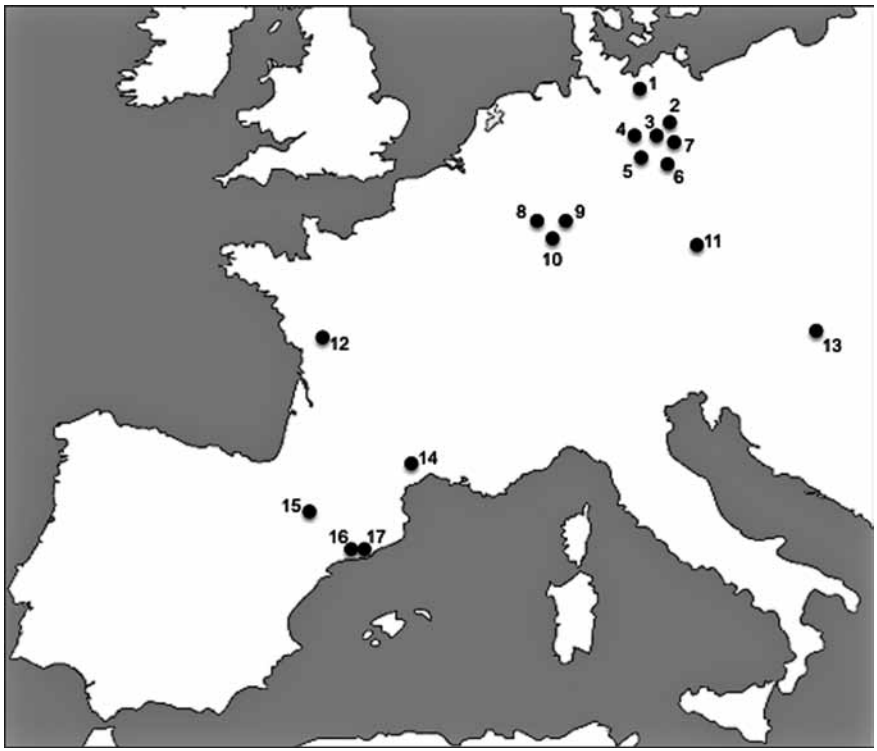

Figure 8.1 Map showing location of Neolithic ancient DNA sites discussed in text. 1) Ostorf, 2) Eilsleben, 3) Derenburg, 4) Unterwiederstedt, 5) Unseburg, 6) Halberstadt, 7) Seehausen, 8) Flomborn, 9) Vaihingen, 10) Schwetzingen, 11) Asaparn Scheltz, 12) Prissé-La Charrière, 13) Ecsegfalva, 14) Cave I, Treilles, 15) Chaves, 16) Can Sadurní, 17) Sant Pau del Camp

The LBK site of Derenburg-Meerenstieg II, Germany has been analysed in more detail. This was a cemetery site used for about 300 years between 5200 and 4900 cal BC (Haak et al. 2010) and excavated between 1997 and 1999. Thirty-two single grave burials were uncovered, as well as one double burial and one triple burial, a total of 41graves in all. A total of 31 individuals were sampled for DNA analysis, five from a previous study (Haak et al. 2005). Some 22 mt DNA sequences were obtained, as well as three Y chromosome sequences, a success rate for mt DNA of 70 per cent showing excellent ancient DNA preservation at this site. When the mt DNA haplogroups were placed on a map of the cemetery no obvious kinship patterns could be discerned, unlike the case of the Canadian pioneer cemetery (Dudar et al. 2003). There were not enough Y chromosome haplogroups obtained to show that a patrilineal grouping of graves might have

existed, as a matrilineal grouping did not. A total of ten mt DNA haplogroups were present in the Derenburg cemetery population – H (2), HV (3), J (3), K (3), N1a (3), T (1), T2 (3), U5a1a (1), V (1) and W (2). This represents a high mt DNA diversity which could result from patrilocal exogamy and fits in with what has been established by Strontium isotope studies at other LBK sites. The single individual with the U5a1a mt DNA haplotype was a mature female – could this be a person who had moved from a gatherer-hunter community? The mt DNA haplogroups present are typically European and most have been discussed above. Haplogroup V is most common today in Northern Spain and in the Saami of Finland at *c*.15 per cent of these populations, and in *c*.10 per cent of the Basques, but much rarer in the rest of the modern European population. Haplogroup W is even rarer today at *c*.< 1 per cent of modern European populations and it might be speculated that the two individuals with this haplogroup might be maternally related in some way, although their graves are some distance apart. However, we have seen that mt DNA haplogroups that are rare today might have been more frequent in the past.

The Y chromosome haplogroups obtained from this cemetery were few. From eight male individuals only three yielded enough Y chromosome DNA to enable a haplogroup to be assigned. Two males belonged to Y haplogroup F* and one to Y haplogroup G2a3. Once again these are too few to confirm whether we are indeed seeing a reduced Y chromosome diversity as predicted for patrilocal exogamy with patrilineality, but it is suggestive and does not contradict that social structure.

Two other German Late Neolithic sites should also be mentioned. Eulau is a Late Neolithic site dating to 2600 BC where four groups of burials were found, a total of 13 individuals including adult males, adult females and children (Haak et al. 2008). All showed signs of violence, similar to that seen at Talheim, with the same population demographic missing, that of female subadults. The bodies were arranged in such a way to suggest that family groups were present, parents and children. In one particularly well preserved burial group, comprising an adult male aged 40–60 years, an adult female aged 35–50 years, and two children aged 4–5 years and 8–9 years, ancient DNA showed that the children were boys who shared the same mt DNA haplogroup K1b as the adult female, and with the same Y chromosome haplogroup R1a as the adult male. The burial group was indeed a family of father, mother and two sons. The adult male's mt DNA haplogroup was different being, haplogroup U5b. Strontium isotope analysis showed that all the adult female had moved from another area while the adult males and children had local Strontium isotope signatures. Another burial group unfortunately did not have such well-preserved ancient DNA so it was not possible to obtain the Y chromosomal DNA, only the mt DNA. Of the 12 individuals sampled for ancient DNA, nine gave results; a success rate of 75 per cent, and five mt DNA haplogroups could be identified. In addition to K1b (3) and U5 b(1) already mentioned, other mt DNA haplotypes included H (1), I (1), K1a2 (1) and X2 (2). So out of nine individuals, six different haplotypes are present. A further two burials were tentatively identified as possibly belonging to mt DNA haplogroups J and N. If this is correct then we would have a total of seven different haplogroups

present in just 11 individuals – this high mt DNA diversity combined with the Strontium isotope evidence confirms the practice of patrilocal exogamy in Late Neolithic Germany.

The Late Neolithic burial site of Ostorf (3200–2950 BC) is unusual in that it represents a gatherer-hunter community surrounded by Neolithic Funnel Beaker farming communities (Bramanti et a*l*. 2009). In other gatherer-hunter communities sampled for ancient DNA, the population predominantly belonged to variants of mt DNA haplogroup U (U, U4 and U5). At Ostorf, seven individuals could be assigned to five mt DNA haplotypes – K(1), J (1), T2e (2), U5 (2) and U5a (1). The presence of what may be thought of as LBK mt DNA haplogroups (J and T2e) must be interpreted with caution – but the thought does occur that these mt DNA lineages could result from the exogamy of farming women into the gatherer-hunter community, and furthermore could this be a mechanism by which gatherer hunters become acculturated and acquire farming? In any case the high mt DNA diversity could be the result of patrilocal exogamy, which is known to have been a social practice of gatherer-hunters both ancient and modern.

Conclusions

The ancient DNA evidence for patrilocal exogamy is patchy as so often we lack the Y chromosome evidence because of its low copy number and generally poor survival. Mitochondrial DNA evidence on its own may not always be conclusive in defining the particular marriage system seen at a Neolithic site. As seen above, high mt DNA diversity could be due to exogamy or a non-strict form of endogamy. However other lines of evidence, such as Strontium and Oxygen isotope analysis, help to confirm the practice of patrilocal exogamy (Bentley 2013), as more variable Strontium isotopic signals are seen in females than males. Whichever marriage system was in use, the mt DNA diversity seen in ancient DNA from Neolithic sites at least reinforces the hypothesis of this chapter that women moved, and patrilocal exogamy remains the most parsimonious explanation for this movement. Patrilocal exogamy is practised by over 70 per cent of the world's populations (http://anthropology.ua.edu/Faculty/murphy/436/kinship.htm). The movement of females between social groups has been happening for millennia, since 'Out of Africa' and before the introduction of farming in Europe. It might be suggested that highly mobile males in prehistory are in fact the exception, as most men would have been involved in a patrilocal, patrilineal kinship system with implications for land ownership and access.

Female mobility is rarely or never used as an explanation of the spread of material culture or technology transfer between communities in prehistory. Vander Linden (2007) suggests that Bell Beaker societies in different parts of Europe were not linked by any single economic network, but a series of short-distance connections. The transfer of pottery technology knowledge needed to make the Bell Beakers implied the movement of people. In effect, the spread of the

Bell Beaker phenomenon was probably facilitated by the exchange of marriage partners between groups. However Vander Linden stops short of saying whether these marriage partners were male or female (or both). From what we have already seen of Neolithic patrilocal exogamy, it is no great leap of the imagination to assume that the mobile marriage partners were women, and that women facilitated the spread of Bell Beaker culture among Bronze Age communities.

Exogamy has been well studied by anthropologists for decades and there is a wealth of literature on the subject. But somehow prehistorians seem reluctant to apply this knowledge to prehistoric societies. By understanding the implications and outcomes of this social practice in prehistory, I believe that new insights will be gained in understanding the role of prehistoric women as the movers, and shakers, of their communities, and the distribution of knowledge and technology should no longer be seen as a male preserve.

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Endnote

The Cambridge Reference Sequence was originally published in 1981 by Anderson et al. It has been re-sequenced and a few minor corrections made to the sequence (Andrews et al. 1999). The new reference sequence is called the rCRS. However, there have been suggestions that the sequence from Mitochondrial Eve, that is the ancestral mt DNA sequence from which all mt DNA sequences descends, should be used as the reference sequence. A new nomenclature of mt DNA haplogroups would result from this proposal.

References

Anderson, S., Bankier. A.T., Barrell. B.G., de Bruijn, M.H.L., Coulson, A.R., Drouin. J., Eperon. I.C., Nierlich. D.P., Roe, B.A., Sanger. F., Schreier. P.H., Smith, A.J.H., Staden, R. and Young, I.G. 1981. Sequence and organisation of the human mitochondrial genome. *Nature*, 290, 457–65.

Andrews, R.M., Kubacka, I., Chinnery, P.F., Lightowlers, R.N., Turnbull, D.M. and Howell, N. 1999. Reanalysis and revision of the Cambridge reference sequence for human mitochondrial DNA. *Nature Genetics*, 23(2), 147.

Barbujani, G., Bertorelle, G and Chikhi, L. 1998. Evidence for Paleolithic and Neolithic gene flow in Europe. *American Journal of Human Genetics*, 62, 488–92.

Bentley, R.A. 2013. Mobility and the diversity of early Neolithic lives: Isotopic evidence from skeletons. *Journal of Anthropological Archaeology*, 32(3), 303–12.

Bentley, R.A., Bickle, P., Fibiger, L., Nowell, G.M., Dale, C.W., Hedges, R.E.M., Hamilton, J., Wahl, J., Francken, M., Grupe, G., Lenneis, E., Teschler-Nicola, M., Arbogast, R.-M., Hofmann, D. and Whittle, A. 2012. Community differentiation and kinship among Europe's first farmers. *Proceedings of the National Academy of Sciences USA*, 109(24), 9326–30.

Bramanti, B., Thomas, M.G., Haak, W., Unterlaender, M., Jores, P., Tambets, K., Antanaitis-Jacobs, I., Haidle, M. N., Jankauskas, R., Kind, C.-J., Lueth, F., Terberger, T., Hiller, J., Matsumura, S., Forster, P. and Burger, J. 2009. Genetic discontinuity between local hunter-gatherers and Central Europe's first farmers. *Science*, 326, 137–40.

Brown, T. and Brown, K. 2011. *Biomolecular Archaeology: An Introduction*. Wiley-Blackwell.

Chaix, R., Quintana-Murci, L., Hegay, T., Hammer, M.F., Mobasher, Z., Austerlitz, F. and Heyer, E. 2007. From social to genetic structures in Central Asia. *Current Biology*, 17, 43–9.

Deguilloux, M.-F., Soler, L., Pemonge, M.-H., Scarre, C., Joussaume, R. and Laporte, L. 2011. News from the west: Ancient DNA from a French megalithic burial chamber. *American Journal of Physical Anthropology*, 144, 108–18.

Della Casa, P. 2011. Mythical voyages and ancestral monuments: Tales on knowledge and leadership in prehistoric Europe, in *Ancestral Landscapes. Burial Mounds in the Copper and Bronze Ages*, edited by E. Borgna and S.M. Celka. Lyon: Maison de l'Orient et de la Méditerranée (TMO 61), 61–74.

Dudar, J.C., Waye, J.S. and Saunders, S.R. 2003. Determination of a kinship system using ancient DNA, mortuary practice, and historic records in an Upper Canadian pioneer cemetery. *International Journal of Osteoarchaeology*, 13, 232–46.

Fitzpatrick, A.P. (ed.) 2011. *The Amesbury Archer and the Boscombe Bowmen. Bell Beaker burials at Boscombe Down, Amesbury, Wiltshire*. Salisbury: Wessex Archaeology (Report 27).

Gamba, C., Fernández, E., Tirado, M., Deguilloux, M.F., Pemonge, M.H., Utrilla, P., Edo, M., Molist, M., Rasteiro, R., Chikhi, L. and Arroyo-Pardo, E. 2012. Ancient DNA from an Early Neolithic Iberian population supports a pioneer colonization by first farmers. *Molecular Ecology*, 21, 45–56.

Haak, W., Forster, P., Bramanti, B., Matsumura, S., Brandt, G., Tänzer, M., Villems, R., Renfrew, C., Gronenborn, D., Alt, K.W. and Burger, J. 2005. Ancient DNA from the first European farmers in 7500-Year-Old Neolithic sites. *Science*, 310, 1016–8.

Haak, W., Brandt, G., de Jong, H.N., Meyer, C., Ganslmeier, R., Heyd, V., Hawkesworth, C., Pike, A.W.G., Meller, H. and Alt, K.W. 2008. Ancient DNA, strontium isotopes, and osteological analyses shed light on social and kinship organisation of the Later Stone Age. *Proceedings of the National Academy of Sciences USA*, 105, 18226–31.

Haak, W., Balanovsky, O., Sanchez, J.J., Koshel, S., Zaporozhchenko, V., Adler, C.J., Der Sarkissian, C.S.I., Brandt, G., Schwarz, C., Nicklisch, N., Dresely, V., Fritsch, B., Balanovska, E., Villems, R., Meller, H., Alt, K.W. and Cooper, A. 2010. Ancient DNA from European Early Neolithic farmers reveals their Near Eastern affinities. *PLoS Biology*, 8(11), e1000536.

Hamilton, S., Whitehouse, R., Brown, K., Combes, P., Herring, E. and Seager Thomas, M. 2006. Phenomenology in practice: Towards a methodology for a 'subjective' approach. *European Journal of Archaeology*, 9(1), 31–71.

Kristiansen, K. and Larsson, T.B. 2005. *The Rise of Bronze Age Society: Travels, Transmissions and Transformations*. Cambridge: Cambridge University Press.

Kumar, V., Langstieh, B.T., Madhavi, K.V., Naidu, V.M., Singh, H.P., Biswas, S., Thangaraj, K., Singh, L. and Reddy, B.M. 2006. Global patterns in human Mitochondrial DNA and Y-Chromosome variation caused by spatial instability of the local cultural processes. *PLoS Genetics*, 2(4), e53.

Lacan, M., Keyser, C., Ricaut, F.-X., Brucato, N., Tarrús, J., Bosch, A., Guilaine, J., Crubézy, E. and Ludes, B. 2011. Ancient DNA reveals male diffusion through the Neolithic Mediterranean route. *Proceedings of the National Academy of Sciences USA*, 108(24), 9788–91.

Lalueza-Fox, C., Rosas, A., Estalrrich, A., Gigli, E., Campos, P.F., García-Tabernero, A., García-Vargas, S., Sánchez-Quinto, F., Ramírez, O., Civit, S., Bastir, M., Huguet, R., Santamaría, D., Gilbert, M.T.P., Willerslev, E. and Rasilla, M. de la 2011. Genetic evidence for patrilocal mating behaviour among Neandertal groups. *Proceedings of the National Academy of Sciences USA*, 108(1), 250–3.

Lasker, G.W. and Crews, D.E. 1996. Behavioural influences on the evolution of human genetic diversity. *Molecular Phylogenetics and Evolution*, 5(1), 232–40.

Pruvost, M., Schwarz, R., Correia, V.B., Champlot, S., Braguier, S., Morel, N., Fernandez-Jalvo, Y., Grange, T. and Geigl, E.-M. 2007. Freshly excavated fossil bones are best for amplification of ancient DNA. *Proceedings of the National Academy of Sciences USA*, 104, 739–44.

Seielstadt, M.T., Minch, E. and Cavalli-Sforza, L.L. 1998. Genetic evidence for a higher female migration rate in humans. *Nature Genetics*, 20, 278–80.

Vander Linden, M. 2007. What linked the Bell Beakers in third millennium BC Europe? *Antiquity*, 81, 343–52.

Walker, R.S., Hill, K.R., Flinn, M.V. and Ellsworth, R.M. 2011. Evolutionary history of hunter-gatherer marriage practices. *PLoS ONE*, 6(4), e19066.

Wilkins, J.F and Marlowe, F.W. 2006. Sex-biased migration in humans: What should we expect from genetic data? *BioEssays*, 28, 290–300.

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Chapter 9
Mobility in the Roman Empire

Lien Foubert and David J. Breeze

Introduction

In recent scholarship, researchers have emphasised the centrality of mobility in the Roman Empire (Horden and Purcell 2000). Individuals and groups moved around, by land and sea, thus connecting various parts of the Mediterranean and bringing the edges of the Empire closer to the centre and *vice versa*. They have left traces of their movements in letters on papyri and ostraca, in graffiti on buildings or monuments, in votive offerings and funerary inscriptions, by means of artefacts or through the texts of literary authors. Generally speaking, two types of travel can be distinguished: short-distance travel within the borders of a single province, and long-distance travel, from one province to another. Travel occurred on a voluntary basis as well as by force, with exiles, slaves or prisoners of war as examples of the latter. Temporary travel could sometimes receive a permanent character, in which case we should speak of migration rather than travel. The motives for travelling may be of a military, political, economical, legal, cultural or familial nature, but were often a combination of these.

The opportunities and limits to travel for Roman individuals have been rarely touched upon in classical scholarship, with the exception perhaps of the travel activities of male aristocrats such as members of the imperial family or governors. One of the reasons for this lacuna may well because it is often assumed that travelling was the prerogative of the male elite and that marginalised groups, like, for instance, women, were not mobile at all, but nothing is further from the truth.

Due to the perceived transgressive nature of travel, past and present societies have often characterised women travellers as troublemakers and accused them of challenging social boundaries. The Roman world was no exception. Judging women travellers in the context of their ideal of female conduct, authors repeatedly disapproved of women who followed their husbands on journeys. It was argued that women who travelled with their husbands obstructed the execution of campaigns, encouraged corruption, and were inclined to intrigue (Tacitus, Annals 3.33 is the classical locus). These ancient disapprovals may have contributed to modern scholars' conclusions that travelling women in the Roman world were almost nonexistent. Only the travels of Christian women in Late Antiquity have become a commonly accepted aspect of ancient female travelling. These travels of female pilgrims are often treated as if they came into being *ex nihilo*, but women in the Roman world had been mobile from the end of the Republican period in the first

century BC onwards. In fact, individuals from all layers of society, of all ages, and women as well as men are attested as travellers, though each of them had different reasons and opportunities to be mobile.

Another reason for the apparent neglect of travellers from marginalised groups in classical scholarship may be that ancient references to these individuals are scattered and difficult to trace. The most accessible way to find them is through the texts of literary authors, though taking the above-mentioned negative opinions into account. But the scholar studying mobility of individuals in the Roman world could benefit more from a combination of these literary sources with non-literary sources, like archaeological remains, inscriptions, papyri, ostraca and graffiti. Much work, however, remains to be done as it is only recently that experts in these fields have found each other with regard to the subject of travel. The present contribution aims at offering an overview of the context of mobility in the Roman world, both the circumstances that enabled and disabled travel, using various types of sources in order to provide a larger picture (though by no means exhaustive) than merely the movement of the male elite.

Though mobility was an omnipresent aspect of daily life before the Roman period, the imperial reign in many ways had made travelling easier. This was addressed by Aelius Aristides, an intellectual from Asia Minor, who in AD 144 undertook a journey to Rome. On 21 April, the day on which the Romans celebrated the foundation of their city, he delivered a panegyric on the glories of Rome and its Empire. He praises Rome for enabling all its inhabitants to travel easily and safely, because:

> on the one hand, you have surveyed the whole world, on the other you have spanned rivers with all kinds of bridges. By cutting through mountains you have made land travel feasible; you have filled the deserts with way-stations, and you have civilized everything with your lifestyle and organisation (Aelius Aristides, *Oration* 101, trans. Talbert 2012).

According to the author, part of the success of Rome's imperial reign depended on its infrastructure and the *Pax Romana*.

What the Romans did for a mobile society

Infrastructure

Travellers could make extensive use of the network of roads which criss-crossed the empire – not all roads led to Rome – and constitute one of the most visible remainders of Roman culture. The construction of these roads was not intended to facilitate the journeys of the private traveller, but aimed at improving Rome's military campaigns and the extensive bureaucracy that came with it, from the top downwards – and upwards. Emperors issued instructions to their governors or

generals and kept a close eye on all senior appointments. Every regiment in the army submitted a report to Rome each year, and within each unit every soldier and every horse had his own file. Receipts for goods could be issued in quadruplicate. An important aspect of that bureaucracy was therefore communication and in order to expedite that an imperial post had been established (Kolb 2001).

In the Republic, governors and generals were responsible for their own despatches, employing their own messengers. The first emperor, Augustus (31 BC to AD 14), brought such arrangements onto a new footing, though the republican practice was maintained by wealthy private individuals during the Empire. Augustus created a regular state post which in Late Antiquity became known as the *cursus publicus*. This was not a unique initiative for both the Parthian Empire and the kingdom of Egypt operated such an arrangement (see, for instance, Herodotus 8.98). A well-known statement by the sixth century author Procopius describes the origin and organisation of the imperial post:

> the earlier emperors, in order to obtain information as quickly as possible regarding the movements of the emperor in any area, sedition, or unforeseen accidents in individual cities, and the actions of the governors and other persons in all parts of the empire, and also in order that the annual tributes might be submitted without danger or delay, had established a rapid service of public couriers throughout their dominions in accordance with the following system. As a day's journey for an active man, they fixed eight stages, or sometimes fewer, but generally not less than five. At every stage there were 40 horses and a proportionate number of grooms. The couriers appointed for the work, by making use of relays of excellent horses, when engaged in the duties I have mentioned, often covered in a single day, by this means, as great a distance as they would otherwise covered in ten (Procopius, *Anecdotes* 30).

Itineraries suggest that the overnight lodgings were 40 km apart with two staging posts between. Important private travellers could claim public hospitality, to which we will return, and be billeted at private houses, no doubt of a scale to reflect their social status. There were also inns for ordinary travellers, and stories of the rapacity of inn-keepers were recorded by Roman writers. In a nutshell, an imperial messenger at the time of Procopius could cover between five and eight stages, that is, between 65 and 100 km: a reasonable average would be about 80 km a day, at a rate of about 8 km an hour (Ramsey 1925 provides corroborative evidence, Casson 1974: 188). Private travellers were much slower, averaging perhaps 48 km a day (Casson 1974: 189–90).

Besides the imperial messengers, the list of officials allowed to use the *cursus publicus* included procurators, senators, knights, centurions and other persons travelling on military service. In order to use the post, a permit bearing the emperor's seal was necessary. Such passports were issued to provincial governors who could use them within a restricted period – like modern 'offers' they were time-limited. Improper use of these permits seems to have occurred on a regular

basis. Pliny the Younger, for instance, wrote a letter to emperor Trajan (AD 98 to 117) to explain to him that he had given such a permit to his wife, because she had received the news that her grandfather had died and he wanted her to be with her family as quickly as possible (Pliny, *Letters* 10.120). Trajan responded with compassion, but not every sovereign was as clement. Pertinax, for instance, before he became emperor in AD 193, set out for Syria as prefect of a cohort, and there, because he had used the imperial post without official letters of recommendation, he was forced by the governor of Syria to make his way from Antioch to his station on foot (*Augustan History*, *Life of Pertinax* 1.5–6).

The cities that were part of this postal network were also responsible for the costs and were required to provide vehicles or animals and to offer hospitality. They either employed a contractor to provide the service on their behalf or requisitioned carriages and mules as the need demanded. An inscription found in modern Turkey, dating to the reign of the emperor Tiberius (AD 14–37), Augustus' successor, describes the arrangements pertaining at the time within the Roman Empire (*SEG* XXVI 1392). The inscription contains a schedule of the services which must be provided by the individual local authorities and was posted in 'the various cities and villages' of Sagalassos. They had to provide ten wagons and as many mules for the necessary use of travellers for which they would be compensated. The ordering or requisitioning of goods by the state in return for compensation paid at a later date, usually at a fixed rate, was a normal arrangement in the Roman Empire (Mann 1985). Since so many messengers did pass through Italy *en route* to Rome, a hundred years after Augustus' reign, the state took over the responsibility of maintaining the service on the main roads there. The burden remained considerable and successive emperors sought to alleviate it.

The Emperor Hadrian (AD 117–138), who certainly undertook some re-organisation, may have been responsible for the creation of the first and second class postal system. The express post was used by the messengers and both horses for riding and mules and horses for pulling the carriages were provided. Three different types of carriages are known, including a two-man gig. The slow post consisted of wagons pulled by oxen and were used, for example, for the movement of bullion and military supplies. By the fourth century, there appears to have been a distinction between the messenger who rode a horse, leading a second, the rider in the express carriage and the ox-wagons. There were also post-boats.

As stated above, the main reason for creating the infrastructure to allow mobility was to facilitate communication. We are fortunate in having some journeys recorded by ancient writers so that we can have an impression of the distance that was covered and the speed at which this occurred. During the Republic, Julius Caesar travelled from the Rhone to Rome in eight days, a distance of nearly 1280 km (Plutarch, *Julius Caesar*, 17, Suetonius, *Julius Caesar*, 57). During the reign of Augustus, Tiberius covered 360 km in twenty-four hours when rushing to his dying brother Drusus in 9 BC in Germany using the imperial post (Pliny, *Natural History*, 7, 84).

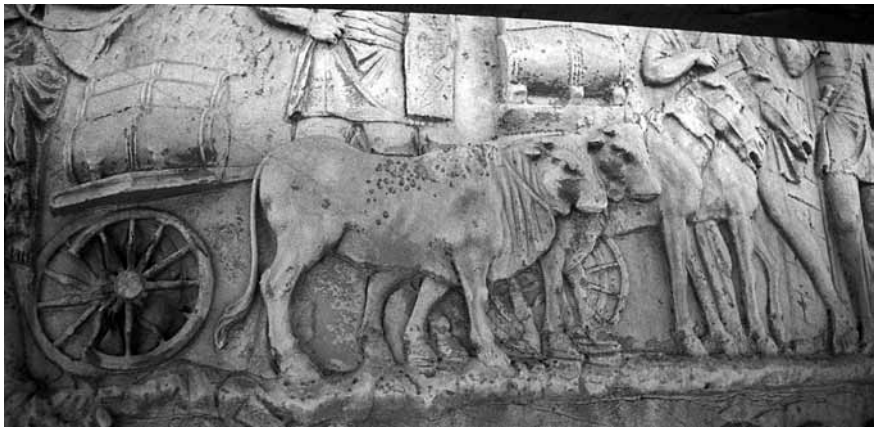

Figure 9.1 Army carts drawn by oxen and mules depicted on Trajan's Column in Rome in the early second century AD
Source: Photograph by A. Lamb; used with permission.

There is more information about the speed of the travel of special news, especially bad news, during the Empire. The events surrounding the death of Nero in AD 68 and his succession are particularly informative. Nero committed suicide (with some help) in Rome on 9 June. The news was carried to the governor Galba, then in the interior of Spain, in less than seven days (Plutarch, *Galba*, 4). Galba made his bid for the purple, but a couple of months later the two legions based at Mainz rose in rebellion against him when they assembled in the morning for their annual parade on 1 January AD 69. A messenger arrived with the news of the revolt in Cologne while the governor Vitellius was having dinner that evening, a distance of 173 km (Tacitus, *Histories*, 1, 12–8, 55–7). The procurator in Rheims to the west of Mainz also learnt the news and sent a messenger to Rome. The distance of at least 2,350 km from Mainz to Rome via Rheims was covered in less than nine days, an average of 260 km a day.

Another imperial murder provides further information on the speed with which bad news travelled. Information about the murder of the Emperor Pertinax in Rome was received by Septimius Severus in Carnuntum, a maximum of 1176 km distance depending on the route, 11 days later: an average of 107 km a day (Eliot 1955). The messenger using the imperial post carried news of the murder of another Emperor, Maximinus, in AD 238 travelled even faster from Aquileia at the head of the Adriatic to Rome, taking just four days, travelling over 120 km a day (*Augustan History*, *Life of Maximinus*, 2, 15). Finally, in the late Empire, the news of the death of the Emperor Constantine, which occurred on 22 May AD 337 at Nicomedia near Constantinople, was received by his son, Constantine II, in Trier at the other end of the Empire shortly before 17 June (Stephenson 2009: 281).

Information is also available on sea voyages. The time from Ostia, the port of Rome, to Tarraco in eastern Spain took five days in favourable conditions. News

of the death of Gaius Caesar, the heir of Augustus, on the south coast of Anatolia on 21 February AD 4 reached Pisa on 2 April, only 40 days later (*ILS* 140). In AD 69, news of the accession of Galba on 9 June was received in Alexandria before 6 July (Ramsey 1925: 69).

Besides references in the works of literary authors, the dating of imperial edicts is also helpful in determining the speed of travel. An edict of the Emperor Caracalla was posted in Rome on 11 July AD 212 and copied in the office of the prefect of Egypt in Alexandria on 31 January AD 213 and published there on 10 February. The Emperor Diocletian issued an edict at Nicomedia in western Asia Minor on 24 February AD 303. It reached Africa on 5 June, less than three months later (Millar 1977: 254). In a review of the length of time it took for edicts to be transmitted across the Empire in the fourth century, Duncan-Jones suggested that the wide discrepancies, including 61 days from Arles to Theveste in AD 316 and 199 from Constantinople to Carthage in AD 363, were due to geography, the time of the year and happenstance as well as perhaps the growth of bureaucracy in the late Empire (Duncan-Jones 1990: 7–29).

Pax Romana

Besides good roads, accommodation and means of transportation, safety was another important catalyst for the increase of mobility. Augustus made the forecast of a peaceful empire part of his propaganda, after which the *Pax Augusta* (the peace ensured by the emperor) or its equivalent the *Pax Romana* (the peace ensured by the city of Rome) stood high on every successive emperor's agenda. Velleius Paterculus, who served as a commander under Tiberius and may therefore not have been very objective, praised his emperor as follows:

> when was the price of grain more reasonable, or when were the blessings of peace greater? The *Pax Augusta*, which has spread to the regions of the east and of the west and to the bounds of the north and of the south, preserves every corner of the world safe from the fear of brigandage (Velleius Paterculus 2.126.3).

The film *Spartacus* is justly famous, but there were bandits at other times as well. During the reign of Septimius Severus (AD 193–211), the imperial peace was challenged by a bandit called Bulla, who robbed travellers using the *Via Appia*:

> at this period one Bulla, an Italian, got together a robber band of about six hundred men, and for two years continued to plunder Italy under the very noses of the emperors and of a multitude of soldiers. For though he was pursued by many men, and though Severus eagerly followed his trail, he was never really seen when seen, never found when found, never caught when caught, thanks to his great bribes and cleverness. For he learned of everybody that was setting out from Rome and everybody that was putting into port at Brundisium, and knew

> both who and how many there were, and what and how much they had with them (Cassius Dio, *History of Rome*, 76.10).

The writer Cassius Dio records that Septimius Severus chided his army officers that his army was winning victories in Britain while Bulla remained at large in Italy. In the end, Bulla was not defeated by the emperor, but betrayed by his lover.

So the question arises: how safe was travel? So far was we can see, at least for the two centuries from Augustus to Severus it was safe to travel, and travelling at night appears to have been common. It is interesting to note that life became less safe during civil wars or when the emperor's attention was distracted. Then, even piracy could be resumed in the Mediterranean and Black Seas. But even when the emperor was in control of the situation, it was wise for travellers to take some precautions. Obviously, it was best to travel as light as possible. If a traveller could not afford to hire armed protection, than he or she should at least carry few valuable items or hide them. In a letter to his wife Ploutogenia, Paniskos asks his wife to travel from the Fayum region in Roman Egypt to Koptos, where she is to reside with him and their relatives. He states that she should only travel when she is able to find 'trustworthy men'. Ploutogenia is asked to bring supplies and all of their clothes, but her husband explicitly asks her to hide her jewellery when she is on the boat (P. Mich. 2.214). The satirist Juvenal, writing in the late first and early second century AD, also acknowledges the risk of travelling with precious belongings:

> though you carry but few silver vessels with you in a night journey, you will be afraid of the sword and cudgel of a freebooter, you will tremble at the shadow of a reed shaking in the moonlight; but the empty-handed traveller will whistle in the robber's face (Juvenal, *Satires* 10.19–22).

The presence of dogs is also attested as a means to chase away robbers, or at least to slow them down. Pliny the Elder lists the examples of the poet Vulcatius and the disabled senator Caelius (Pliny, *Natural History*, 8.144–7). The former was protected by his dog during an attack after nightfall when returning from his palace near Rome, the latter came across bandits near Piacenza and did not receive a blow until his dog was killed. Pliny does not state how the tale ended, but one can imagine. Bandits were not only feared because they robbed travellers from their belongings. A tombstone set up by Limbricia Primigenia tells us how her husband, Gaius Tadius Severus, 35 years old, was abducted by bandits (*ILS* 8506). Other funerary monuments from all over the Roman Empire inform us of travellers who were murdered or deceived by brigands (e.g. *ILS* 2011, 5112). Even being a member of the imperial family was not always a protection in itself. Ammianus Marcellinus records a raid of the Quadi in AD 374 in which Constantia, daughter of the Emperor Constantius, was nearly captured when travelling to marry the Emperor Gratian: she was saved by the prompt action of the governor

of the province – and divine intervention (Ammianus Marcellinus, *A History of Rome*, 29, 6, 7).

The dangers of travelling by sea were similar. The *Acts of the Apostles* (chapter 27) vividly describes St Paul's shipwreck *en route* from Judaea to Rome, but piracy could also be a plague. Philo of Alexandria praises Augustus because he had emptied the seas of pirates and filled them with merchants (Philo, *Embassy to Gaius* 2.146). The geographer Strabo explains that it was easier for ships to reach distant areas, which consequently enhanced commercial activities, when piracy was taken care of by the Roman authorities (Strabo, *Geography* 3.2.5). The main victims of these bandits would have been traders, but individual travellers sometimes bought a passage on one of the merchant ships as well. Funerary inscriptions bearing sad stories about sea voyages that went wrong are illustrations of this, like for instance the tragic account of the death of Cornelia Tyche and her daughter Iulia Secunda, found on a funerary monument at the Campus Martius and dated to the second century AD (*CIL* 6 20674). Judging from the size of the monument and the quality and quantity of its memorial carving, the women belonged to a wealthy family. Of their memorial, only the front panel has survived, containing a dedication to and a portrait of each woman. Attributes of the goddesses Fortuna and Diana appear on the upper part of the panel, constituting on the one hand a pun on Cornelia Tyche's name and on the other an association of her daughter with Diana, a common practice when representing young girls. When looking at the side of the panel, you can still see traces of another inscription which belonged to the same monument. The rest of this inscription is now missing, but a drawing of the monument in its (more or less) original form survived in a drawing dated to the sixteenth or seventeenth century. In the inscription on the side panel, the fate of the 39 year old Cornelia Tyche and the 11 year old Iulia Secunda was described by Julius Secundus, husband and father, in a Latin poem in dactylic hexameter: their ship sank in a storm somewhere on the coast between Marseilles and the mouth of the Ebro.

Considering the potential risks of travelling by land and sea, it is not surprising that many turned to the gods to ask protection during the journey. As Aelius Aristides says: 'it is a time-honoured custom of travellers setting forth by land or sea to make a prayer pledging the performance of some vow – whatever they have in mind – on safe arrival at their destination' (Aelius Aristides, *Oration* 1). In this writer's case, the vow he made to the gods after his arrival in Rome was the above-mentioned panegyric, from whence this quote stems. Other travellers dedicated a memorial to the gods, which could take various forms and could be aimed at a variety of divinities. Some dedicated a set of footprints, imprinted in stone, accompanied by the legend '*pro itu et reditu*', asking divine protection for the journey and back. Others dedicated a monument to Jupiter Optimus Maximus, to the deities who protected the crossroads (the Quadruviae, Triviae or Biviae) or to Silvanus, who watched over the woodlands. Presumably, all depended on the type of journey that lay ahead (or behind) of the traveller. All in all, both the *Pax Romana* and the *Pax Deorum* was needed to ensure a safe passing.

Figure 9.2 Tents being transported by ship across the River Danube during the campaigns of the Emperor Trajan against the Dacians in the early second century AD
Source: Photograph by David J. Breeze.

Epilogue: A cosmopolitan world

The opportunities for mobility, which were enhanced by a safe empire, especially in the first and second centuries AD, helped to create a cosmopolitan world, as we can see, for instance, from the New Testament, especially the *Acts of the Apostles* and the letters and travels of St Paul. This was by no means unique. To take some evidence from Britain alone: the tombstone of Barathes of Palmyra on the eastern frontier of the empire lies at Corbridge just south of Hadrian's Wall (*RIB* 1171). At South Shields, at the mouth of the River Tyne a man named Barates also from Palmyra, and possibly the same man, erected a tombstone to his wife, Regina, a freedwoman of the tribe of the Catuvellauni, who lived in what is now the Home Counties north of London. The funerary inscription is written both in Latin and in Palmyrene (*RIB* 1065). At Brough-under-Stainmore was buried Hermes of Commagene, his epitaph in Greek (*RIB* 758). A final example in Greek from Corbridge attests to the presence of a woman who travelled from East to West: 'To Hercules, the Tyrian, Diodora the high-priestess (has set this up)' (*RIB* 1129).

The army, of course, provides many examples of the cosmopolitan nature of the Roman Empire, including people from elsewhere serving in Britain. Claudius Charax from Pergamum in modern Turkey commanded the Second Legion during

the invasion of Scotland in AD 139/40 (*AE* 1961: 320, Birley 2005: 253–4). Lucius Antistius Lupus Verianus from Sicca in North Africa commanded the regiment based at Maryport on the Cumbrian coast, as did Marcus Censorius Cornelianus from Nemausus (modern Nîmes) in Provence (*RIB* 816 and 814). Caecilius Avitus, Gaius Lovesius Cadarus and Quintus Postumius Solus all from Merida in Spain served in the Twentieth Legion stationed at Chester (*RIB* 492, 501 and 502). Gemellus, son of Breucus, from Pannonia (modern Hungary) served in the First Tampianan Cavalry Regiment of Pannonians in Britain (*CIL* 16 69). Gemellus was unusual in returning home at the end of his 25 years' service; most soldiers on retirement appear to have stayed close to where they served, adding to the genetic mix of the Roman world.

As a result of the cosmopolitan nature of the Empire in general and its cities in particular, one could argue that a new phenomenon saw the light, namely that of tourism. Though the origins of tourism are often placed in the mid-nineteenth century, with the rise of mass tourism, patterns of a tourist industry, if one could call it that, can be traced in the Roman imperial period as well (Friedländer 1907: 323–94, Foertmeyer 1989, Lomine 2005). Greece and Egypt were favourite locations and, from the fourth century AD onwards, the Holy Land. On the pyramid of Cheops, for instance a certain Terentia (*ILS* 1046a) inscribed a poem, in which she displayed her erudition by adopting phrases from Ovid and Horace, and in which she lamented for the fact that her deceased brother was not there to see the famous sights. The graffiti in the tombs of the Valley of the Kings or on the Colossi of Memnon, famous tourist attractions then and now show us in whose company visitors travelled, where they came from and what their social background was. In about AD 160, Pausanias wrote a guide-book to Greece and later there were guides for travellers to the holy sites associated with Christ. There even seemed to have been a souvenir industry. Near modern Lisbon, a glass vial was found which showed the 'skyline' of Puteoli, including amphitheatres, an arcade promenade, baths and a pier. Similar artefacts with pictures of Baiae, one of the most popular seaside resorts in Roman times and now, were found in northern Italy and in Rome. The significance of these and other objects related to tourism, or more general to movement and mobility, remain unclear. To gain a better understanding of the impact of mobility on the material culture of the Roman Empire and on the socio-cultural development of individuals and groups, further collaboration between various disciplines is necessary.

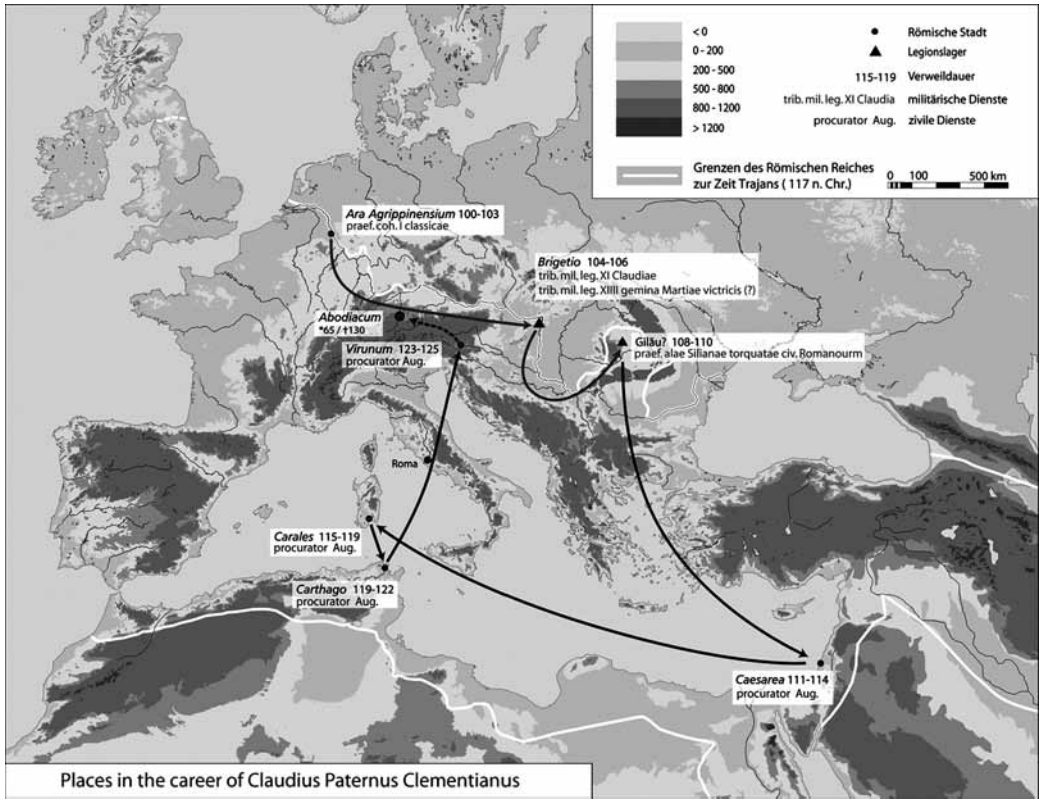

Figure 9.3 A map illustrating the movement of Claudius Paternus Clementianus across the Empire during the course of a career which saw him serve on the Lower Rhine, the middle Danube, Transylvania, the Middle East, Sardinia, North Africa and finally Austria

Source: Illustration from S. Broedecker, J. Kunow, H.J. Laufferr/LVR-Amt fur Bodendenkmalpflege im Rhienland; used with permission.

Abbreviations

AE L'Année épigraphique
CIL Corpus Inscriptionum Latinarum
ILS Inscriptiones Selectae Latinae
RIB The Roman Inscriptions of Britain
SEG Supplementum Epigraphicum Graecum

References

Birley, A.R. 2005. *The Roman Government of Britain*. Oxford: Oxford University Press.

Casson, L. 1974. *Travel in the Ancient World*. London: George Allen & Unwin Ltd.

Duncan-Jones, R. 1990. *Structure and Scale in the Roman Economy*. Cambridge: Cambridge University Press.

Eliot, C.W.J. 1955. New evidence for the speed of the Roman imperial post. *Phoenix*, 15, 76–80.

Foertmeyer, V.A. 1989. *Tourism in Graeco-Roman Egypt*. Unpublished PhD dissertation, Princeton University.

Friedländer, L. 1907. *Roman Life and Manners under the Early Empire*. London: Routledge and Kegan Paul.

Horden, P. and Purcell, N. 2000. *The Corrupting Sea. A Study of Mediterranean History*. Oxford: Blackwell.

Kolb, A. 2001. Transport and communication in the Roman state; the Cursus Publicus, in *Travel and Geography in the Roman Empire*, edited by C. Adams and R. Laurence. London: Routledge, 95–101.

Lomine, L. 2005. Tourism in Augustan society (44 B.C.–A.D. 69), in *Histories of Tourism. Representation, Identity and Conflict*, edited by J.K. Walton. Clevedon: Channel View, 69–87.

Mann, J.C. 1985. Two 'topoi' in the Agricola. *Britannia*, 16, 21–4.

Millar, F. 1977. *The Emperor in the Roman World (31 BC–AD 337)*. London: Cornell University Press.

Ramsey, A.M. 1925. The speed of the Roman imperial post. *Journal of Roman Studies*, 15, 60–74.

Stephenson, P. 2009. *Constantine, Unconquered Emperor, Christian Victor*. London: Quercus.

Talbert, R.J.A. 2012. Roads not featured. A Roman failure to communicate?, in *Highways, Byways and Road Systems in the Pre-Modern World*, edited by S.E. Alcock, J. Bodel and R.J.A. Talbert. Cambridge: Cambridge University Press, 235–54.

Chapter 10
Travelling by Water. A Chronology of Prehistoric Boat Archaeology/Mobility in England

Mark Dunkley

Introduction

On a clear day, it is possible for one to see the coast of France from Deal, east of Dover, to Hythe, west of Folkestone. The light also plays a part, for visibility for those viewing south-east England from the Continent will be better because of the position of the sun. As the most recent increase in sea levels approached current levels at the start of the Neolithic period, it is not hard to imagine our ancestors looking north from Nord-Pas-de-Calais and marvelling at those who had the wherewithal to cross the ocean.

This chapter presents a rapid survey of the range and chronology of prehistoric watercraft as they relate to England, based upon key archaeological discoveries. Significant vessel types are identified irrespective of the original environment they navigated, and gaps in our understanding are noted. It is not intended to set out a comprehensive review of known craft or archaeological sites nor is it a synthesis of very early British maritime history but it does address vessels used on inland waters, coastal waters and the open sea, as well as those vessels now abandoned in coastal areas. It includes vessels that are buried under the ground where reclamation or some other process has caused a former waterway to be covered by dry land: many of the most significant early boats and ships have been discovered on land rather than at sea.

Above all, this chapter seeks to present watercraft as a *means* of mobility and to draw attention to such craft in the study of movement, migration and trade throughout prehistory. The opportunities for mobility presented by watercraft enabled our ancestors to undertake riverine, estuarine, coastal and oceanic passage.

Watercraft remains, including their cargoes, provide important information about social, economic and political circumstances at the time of their build, use or loss. It is therefore important to remember that objective assessments of evidential, historical, aesthetic and communal values associated with vessel remains can assist in articulating their special interest and informing conservation management.

(Pre-)Historical Overview

Early prehistoric (500,000–4000 BC)

It is believed that Palaeolithic watercraft in North-West Europe was most likely limited to the use of log or hide floats and/or rafts in inland waters, particularly as there is no evidence for the waterborne movement of peoples between the British landmass and Continental Europe during pre-Holocene interglacial periods (i.e. before *c.*12,000 BP).

Given that the settlement of the Inner Hebrides and Ireland during the ninth millennium BP, for example, would have been impossible without an effective means of water transport, it is easy to speculate on the development of water transport during the early prehistoric period. Such speculation is widespread and some commentators have even suggested that the first boat, as opposed to a log 'raft', may have simply been a log hollowed out by disease. However, there is parallel evidence of early 'boat'-building capabilities in the form of paddles dated to the tenth to fifth millennia BP in northern Europe, particularly from areas surrounding the Baltic Sea (Burov 1996). In every case, paddles appear much earlier than logboats in the same areas thus giving rise to the likelihood that other vessels must have been utilised which, Lanting (2000) has argued, were almost certainly skin- or barkboats.

The clearest evidence for boat-based mobility in the early prehistoric period derives from Alta, northern Norway, in the form of rock carvings. Recently re-assessed to date from the late seventh millennium BP (Gjerde 2010), the art shows a culture adept at boat building (Figure 10.1). Small fishing boats appear from the earliest drawings onward with later drawings showing larger boats, some carrying up to 30 people and being equipped with elaborate, animal-shaped decorations on bow and stern (which may be interpreted as the predecessor to figureheads).

In his thesis, Gjerde (2010) argues that the rock art of northern Norway acts as geographical references to the hunter-fisher-gatherer landscape from the deliberate choice of the rock art site to the placing of the rock art on the actual rock surface.

Archaeological evidence for such craft is incredibly rare: worked reindeer antlers from the area Schleswig-Holstein in northern Germany, which may have been used as frames on skin-boats, have been dated to the Ahrensburgian culture. This nomadic culture extended from western Poland to south east England during the Late Upper Palaeolithic *c.*11,500 BP and it is likely that the skin-boats would have been limited to use on inland waters associated with reindeer migration. Data compiled by Luukkanen (2009) indicates that the skills needed to build such craft were developed in the tundra or tundra/taiga border zones associated with reindeer territories, first along rivers and coastal areas, before becoming fully adapted to maritime environments in order to hunt marine mammals. Boat-based mobility, therefore, may well have commenced as a response to early subsistence modes (i.e. hunting and artisan fishing) rather than as a means to enable human migration in the late Pleistocene. Such evidence is not yet known in Britain, but the recent

discovery of a reindeer carving in Cathole Cave, South Wales, with a confirmed minimum date of 14,505 ± 560 BP (BBC News 2012) hints at comparative skin-boat-based hunting across the continent.

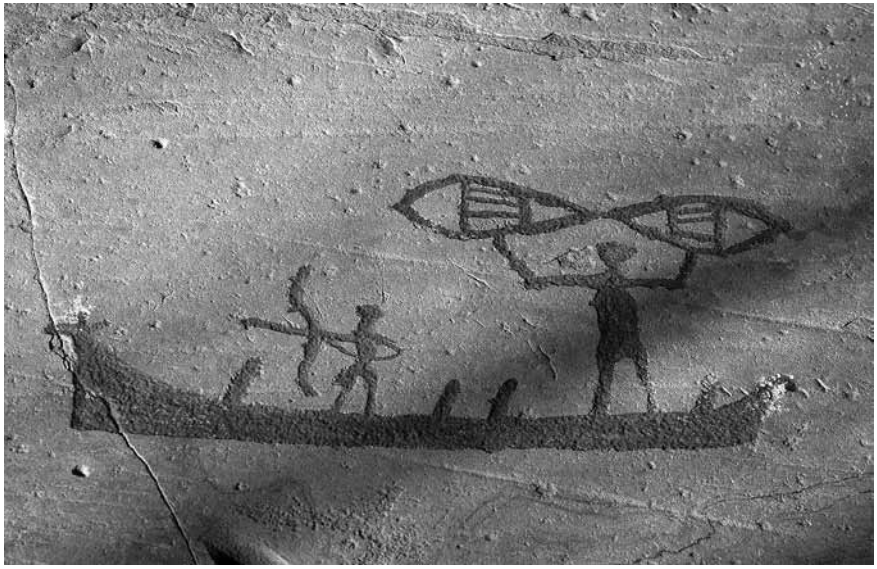

Figure 10.1 A prehistoric culture adept at boat building. Evidence from the late seventh millennium BP in Alta, northern Norway, provides clear evidence of prehistoric boat-based mobility

Source: Photograph by Per Storemyr; used with permission.

However, the separation of the British Isles from the north-west European peninsula at the end of the last glacial period around 12–13,000 years ago necessitated contact across the English Channel and southern North Sea to be by some form of vessel. Multiple-hide boats, perhaps similar to coracles, and basket boats are thought to have been capable of sea voyages at this time. Indeed, Van de Noort has suggested that as a series of islands may have existed in the southern North Sea basin during the glacial retreat. Contact across the wider Channel area may, therefore, have taken 'the form, for a relatively short period, of short-distance island-hopping rather than sea crossings' (Van de Noort 2011: 7).

On the basis of the current evidence, boat-based mobility during the very early Holocene relevant to this chapter appears focussed across the Southern Bight area, that is, the area of the southern North Sea between Flanders and the Thames Estuary.

While Western European peoples of the Early Mesolithic were able to burn out large cavities in wood, there is no certainty that objects such as the 4.5 m

long Perth 'dugout' discovered in the mid-nineteenth century (with a cavity 1.8 m long and 0.6 m deep) were used for water transport. However, migrations and subsistence economies associated in Mesolithic north-eastern Europe which permitted a shift toward sedentism in places favourable for it seems to have enabled a new development of water transport (Burov 1996).

Logboats (also referred to as 'dugouts' and called 'monoxyls' in many European languages, from the Greek *mono* – single, and *xylon* – tree) from the Early/Late Mesolithic transition are known in central north-west Europe, such as those from the Seine valley area south-east of Paris (Bonnin 2000), Pesse in the Netherlands and Hardinxveld-Giessendam also in the Netherlands (Lanting 2000). While the oldest logboats are made from pine (as relicts of the post-glacial forests), there appears to be a clear shift towards soft and easily workable woods such as lime, alder and poplar/aspen during the Late Mesolithic (Lanting 2000: 645). Oak appears to have been exploited only from the Neolithic, most likely reflecting tool adaptation and climate change. However, none of these crafts are associated with coastal navigation, rather they appear limited to use on inland waterways, perhaps aligned with traditions associated with faunal migration.

Logboats are well suited to the relatively gentle pace of river travel, though greater effort is clearly needed for control in fast-flowing water and to paddle upstream. Distances of up to 40 km downstream during sufficient daylight hours are likely to have been achievable (based on this authors' own, if exhausting, experience on the River Wye, Herefordshire).

By the fourth millennium BC logboats were being adapted to include the use of a transom (a vertical board that forms the flat back panel at the stern of a vessel), such as that recorded at Tybrind Vig in southern Denmark (Anderson 1987). This site, lying some 250 m from the present shoreline, once comprised a sheltered inlet/lagoon protected from the open marine environment by a reef or barrier island. Significantly, Pickard and Bonsall (2007) note that the inlet was connected to the sea in the north-west and it may be that this marine connection played some part in enabling logboat development. The additional carrying-capacity afforded to a logboat by a transom may have enabled greater ranges to be achieved and explored thus the transom may have some association with coastal passage and mobility (though Burov (1996) suggests that the skin-boats represented in Norwegian Stone Age rock carvings with a direct keel, steep bow and frame with projections provide an indication of the nature of Mesolithic craft and would also have provided a viable means of sea transport).

While the early logboats in Europe are concentrated on the Continental side of the Southern Bight and Dover Strait, the diffusion of construction technologies and use towards the north and west is far from clear. With the exception of a birch-wood paddle recorded at Star Carr, Yorkshire, and a Late Mesolithic/Early Neolithic burial in a partially burnt dugout canoe found at Parkbury, St. Albans in 1988 (Niblett 2001), physical evidence for vessels in the early prehistoric period in England remains elusive. As the earliest dated logboats in Ireland are Late Mesolithic/Early Neolithic compared to Early Bronze Age for Britain, Lanting

(2000) offers a simple, though fiercely contested, observation that British logboats may have developed from those introduced into Ireland during the Neolithic. Although it is probable that dugout canoes were used by Mesolithic peoples as well as log rafts, log boats and bark boats, as yet, there is no direct evidence of their use as watercraft in Britain.

Late prehistoric (4000–54 BC)

Evidence from the North Sea shows a consistent sequence of events; a period of marine regression (lowering of sea-level) followed by one of transgression (rising of sea-level). Similar evidence is recorded on the French coast from Picardy to Normandy and Brittany, though the most recent increase in sea levels approached current levels at the start of the Neolithic around 6000 years ago. Vessels traversing the western seaways were fundamental to the spread of Neolithic farming, funerary and other systems from the Continent during the early part of the Late Prehistoric period. Debate about indigenous or immigrant origins for the Neolithic in Britain was re-opened recently by the identification of a saddle-quern at Maiden Castle, Dorset, which originated in central Normandy (Peacock and Cutler 2010). The quern is the largest and heaviest Neolithic import yet identified and has led to an examination of the type of boat that crossed the Channel during this early period.

There is evidence of considerable mobility during the Neolithic: for example, the wide distribution of axes from specialised quarries, the movement of pottery from Cornwall into Wessex and cross-Channel contact evidenced by a few Breton axes from Plussulien, Brittany, in the Wessex area. In particular, a concentration of jadeite axes derived from the Italian Alps and concentrated in the Wessex region are likely to have arrived as a result of exchange, although Sheridan (2007) claims they could equally have been treasured heirlooms of immigrant people. It is currently believed that the arrival of the Neolithic in and around Britain and Ireland *c*.4000 BC most likely happened across the western seaways – an arc of sea extending approximately from the Channel Islands in the south, through the Isles of Scilly, the Isle of Man and the Hebrides, around to Orkney in the north. It is noteworthy that this proposes a shift in contact/migration contrasting with the very early Holocene where evidence is focussed across the Southern Bight area.

Clearly, Neolithic peoples were accomplished seafarers and able to cross the English Channel (which is some 29 km at its narrowest point between Dover and Cap Gris-Nez). This whole area is shallow and contains a number of sandbanks in mid-channel which, when combined with strong winds, give rise to dangerous breakers. In addition, seiches (short period oscillations in sea level) may be caused by abrupt changes in meteorological conditions, such as the passage of an intense depression – the English Channel area is frequently affected by east-moving depressions from the North Atlantic Ocean. Persistent strong winds from any quarter can induce a surface current which may exceed the rate of tidal streams through the Strait and thus, when coupled with topographic shoals and seiches

would have caused additional dangers for early navigators in whatever type of craft they employed.

Deer skin (inclusive here of elk and moose hides, for simplicity) canoes are known from the reindeer zone, that is from the boreal forest to the sea coasts in the north and are largely associated with riverine mobility. Fastened by various techniques of lashing or sewing, the skin-boats may well have been carried at portages in the interior of Eurasia. While the earliest evidence of a skin-covered kayak is dated *c*.2000 BP, Luukkanen (2009) claims that the tradition is much older with a convergence on the Arctic north along the great rivers, enabling the development of craft used in the open sea or at the coast for whaling, sealing, and polar dolphin or walrus hunting. The reconstructed skin-boat in the Alta museum is representative of such craft (Figure 10.2) while a wooden elk head dated *c*.5700 BP from Lake Lehtojärvi, North Finland may have been used as a figure-head similar to those depicted on the rock carvings at Alta.

Figure 10.2 Representative of craft used for hunting in the Arctic north, this reconstructed skin boat in the Alta Museum, Norway, shows an elk-headed carving at the bow

Source: Photograph by Per Storemyr; used with permission.

Luukkanen (2009) observes that in reindeer territories, the traditional hunting method was to spear the wild reindeers from small deer skin canoes at a water crossing, on their seasonal migration from the forest to the coast in spring and back to the forest in autumn. Close to the big river estuaries in the north, where dolphins were hunted, similar deer skin boats were probably used.

However, there is no evidence of large-scale mobility or migration in skin- (or birch bark for that matter) boats during the later prehistoric period, and no evidence for their use in maritime contexts in southern Europe (though it is reported that in 1974 a Welsh coracle piloted by one Bernard Thomas of Llechryd crossed the Channel in 13½ hours and Tim Severin's reconstructed Brendan Voyage made such crossings a possibility in antiquity (Severin 2000).

This, then, brings us to the type of vessel capable of transporting the Maiden Castle quern across the Channel. In England, Neolithic dugout canoes are only known from Bexley, Greater London (discovered 1885), Jaywick, Essex (discovered 1936), Whittlesey, Cambridgeshire (discovered 1979) and East Rea, Peterborough (also discovered 1979), although it is not known whether these vessels would have been suitable for offshore navigation. The Czech *Monoxylon* expeditions of 1995 and 1998 led by Radomír Tichý however, saw the reconstruction of logboats (monoxyls) able to cross 300 km between Aegean Islands and tested on the Atlantic seaboard of Portugal (Tichý nd). Remarkably, these logboats were able to navigate in Force 7 to 9 winds (i.e. high winds to strong gales) and two metre high swells. On the Atlantic coast, as strong surf and wave breakers made it impossible for the monoxyls to land outside protected harbours, the importance of sheltered places like Christchurch Harbour/Hengistbury Head, the Solent estuaries and Poole Harbour in the Neolithic can be appreciated for the opportunities they presented for cabotage, that is, the practice of trade or navigation along a coast from one inlet or harbour to another.

Navigation across the Channel would not have been easy. The predominant surface current flows from west to east as a rate of about one knot, but persistent strong winds can induce a wind-driven current which can exceed the rate of tidal streams. In particular, strong winds from the east can give rise of rough and very rough seas. Indeed, whenever a strong tidal stream is running in the opposite direction to a strong wind, the height and steepness of the waves are increased. The addition of a sail to aid such cross-Channel passage in antiquity is not an unreasonable assumption for in 1953 parts of a logboat (dated to 160 ± 44 AD) were found in the Lecker Creek, Schleswig-Holstein, Germany, having traces of a mast foot (Ellmers 2008). Peacock and Cutler (2010) argue that logboats, for which there is evidence, should not be overlooked in favour of skin-boats for which there is none as a means for watercraft mobility in the Neolithic.

At present there is a paucity of evidence for the continued use of logboats during the Early Bronze Age in England, despite evidence of continued cross-Channel contact, such as the Amesbury Archer (whose burial supports interpreters who claim that the diffusion of Beaker Culture pottery was the result of population movement, rather than just the widespread adoption of an artefact type – also see Brown, Chapter 8).

Recent work by Mainberger (2008) has audited the large number of Early Bronze Age logboats discovered in southern Germany. One in particular, catalogued as 'Degersee 2004', comprises the oldest known watercraft in Germany (dated to 3550 ± 15 BP). Importantly, Degersee 2004 exhibits the earliest identified use

of a transom in the Bronze Age enabling the craft to have a greater load capacity. The alder transom board fits into a transverse slot in the logboat with moss serving as a caulking material to fill gaps between the slot on the board.

The earliest use of a transom so far identified in England comes from the Must Farm assemblage, Cambridgeshire. Here, the Cambridge Archaeological Unit, University of Cambridge, in collaboration with Hanson UK, continue to excavate intact deposits that were lost to rising sea levels over three thousand years ago. Bands of waterlain sediments have preserved evidence of prehistoric occupation including remarkable organic remains. Neolithic pavements, Early Bronze Age fence lines and Late Bronze Age pile dwellings represent just a few of the discoveries and, most recently, the investigation of 150 m of prehistoric river channel has so far uncovered nine logboats.

These boats survived deep within the waterlogged sediments of a later Bronze Age/earlier Iron Age watercourse that Knight (2012) has described as once meandering across the southern half of the Flag Fen basin. Coupled with other structures (hurdles, posts, fish-weirs and traps) and artefacts (including swords and spears), the boats provide evidence of a once bustling waterway (Knight 2012), not unlike conditions associated with the Federsee Bog in Upper Swabia, some 40 km north of Lake Constance. Here, Mainberger (2009: 4) describes 'a tangle of waters, with areas of open water interconnected by shallow channels, reeds and bogs, and with arable land only on the drumlin islands.' At Must Farm, Knight (2012) describes the watercourse perched within a roddon or levee; 'we can envisage a natural causeway that flanked a small stream … that made its way through a saturated landscape of marsh and reed swamp. The people who navigated up and down the channel could also have walked along its banks.'

It is unnecessary to emphasise that the availability of watercraft must have been essential in such an environment and Mainberger (2009) has even suggested that the physical vessel might easily have had a function beyond simple use for fishing and transportation, particularly in relation to cosmologies and rituals. Parallels here might easily be drawn in relation to the 'sun boat' on the Nebra sky disc.

As with Degersee 2004, many of the boats in the Must Farm assemblage demonstrate use of a transom and are dated to the early thirteenth century BC. While these boats can claim the earliest evidence of a transom so far identified in England, they must derive from an earlier tradition of boat mobility.

One of the Must Farm boats has an integral cleat carved in to its bow end (Figure 10.3). One interpretation of the use of this cleat is that it provides a suitable place for securing a bowline, but comparisons with the Siljan logboat (discovered in 1930 in Telemark, Norway) is that the cleat was most likely used as a handle (Nymoen 2008). The Siljan boat (*c*.240±70 AD) was discovered in the middle of a system of waterways extending 24 km from the fjord town of Larvik to a broad mountainous region in the north. Combined with place-name evidence, Nymoen (2008) suggests that the cleats on the Siljan boat would have facilitated portage along the watercourses at appropriate places; comparable to the roddons at Must Farm.

Figure 10.3 Detail of one of the Must Farm logboats, discovered in Whittlesey, Cambridgeshire in 2012, showing an integral carved cleat which most likely served as a handle facilitating easier portage

Source: Photograph by Paul Stamper; used with permission.

However, the most far-reaching innovation in vessel construction at this time was the introduction of plank construction, whereby cut planks were fastened (in most cases, stitched with yew withies) together to form a watertight hull. Although the precise date of this innovation is not known, it has been suggested (although no examples have been found) that simple plank boats may have traversed inland waterways during the Neolithic. The earliest seagoing stitched boats yet discovered are a collection of three Middle Bronze Age vessels discovered at Ferriby, Yorkshire, in 1937 and the Dover Boat discovered in 1992 in addition to fragments from the Test Estuary near Southampton and Kilnsea in the Humber region. These are, in fact, the oldest known examples in the world.

The location of these discoveries, either at the coast or in estuaries, has given rise to the belief that sewn-plank boats were used for oceanic passages, though their suitability for such journeys continues to be debated. The Ferriby craft are thought to have been around 16 m long while that at Dover has a minimum length of 9.5 m. Such vessels were probably too large to navigate in inland waters and, in the absence of smaller plank-built vessels, it is likely that dugout canoes were utilised in these contexts. In addition to those at Must Farm, only two other dugouts discovered in northern England (the Chetwynd boat, found in Shropshire in 1981, and the Shardlow boat, found in Derbyshire in 1998 with its cargo of sandstone)

may represent such craft. However, a 12 m long flat-bottomed raft was discovered at Brigg, Lincolnshire, in 1888 which was clearly unsuitable for coastal passage having a freeboard of about only 0.3 m.

However, the sea-going capabilities of sewn-plank craft were tested on a half-size replica of the Dover Bronze Age boat, named *Boat 1550 BC*, in May 2012. Unfortunately, sea trials were aborted when the vessel began to take on water. Nevertheless, it is relevant that this EU-funded replica was undertaken as a celebration of the technological skills of our Bronze Age ancestors and a symbol of the maritime links that brought together the prehistoric communities of the cross-channel euroregion. Another current project to build a replica a Bronze Age sewn-plank boat comprises collaboration between the University of Exeter and the National Maritime Museum Cornwall. This project intended to find out more about the processes behind building a sewn-plank boat, to examine the seaworthiness of such vessels [and thus determine endurance] and to understand how it was built and sailed. Sea trials of the replica were successfully undertaken in March 2013 with headlines proudly proclaiming that it did not sink (Keys 2013).

The quantity of imported material discovered during terrestrial archaeological investigation indicates the amount of cross-Channel trade taking place before the Roman conquest in AD 43. The proximity of the Dover Boat to the protected Bronze Age artefact assemblage discovered offshore in Langdon Bay, Kent, provides *in situ* evidence of cross-Channel trade and contact. Material from other protected underwater assemblages off Salcombe and Moor Sands, Devon, possibly represents cargo from ocean-going vessels. Here, discovery by the South West Maritime Archaeological Group of an enigmatic *strumento con immanicatura a cannone* (literally, an implement with a cannon-shaped handle. Accessioned by the British Museum, registration number: 2005,0503.3) is paralleled only on a class of object peculiar and exclusive to Sicilian late prehistory (Parham et al. 2006). Further finds (though, sadly, no organic boat remains) from off Southend, Hayling Island and Bournemouth, coupled with a possible Bronze Age assemblage of tin ingots discovered from a protected site at the mouth of the River Erme in Devon, indicate complex trade routes having been established by this time; such connections have frequently been deduced from terrestrial discoveries, but are rarely attested directly.

Other than Lecker Creek logboat referred to above, no firm evidence for the use of sails at this time has yet been discovered. As such, it is believed that propulsion was by punting (for rivers) or paddling; it is thought that the Dover Boat could accommodate at least 18 paddlers. A two metre long oak paddle discovered at Canewdon, Essex, in 1983 showed no traces of having been used as an oar or steering oar, suggesting its use was most likely used as a paddle.

Intriguingly, a recent discovery from the Isles of Scilly may provide evidence of the earliest image of a masted ship yet found in Britain. A fragment of Late Bronze Age pottery (dated *c*.1000–800 BC), found during an excavation in 2012 had a series of lines scratched on to the surface before the object was fired which, if confirmed, appears to represent the hull and mast of a boat pre-dating other known

images of this kind of vessel by centuries (Anon 2012). Previous representations of masted boats were not known in England until the first century BC and we can only begin to speculate as to what cargo capacity such a vessel may have had and where and how such a vessel may have been built. Indeed, could this fragment of pottery be the earliest representation of a *ship* in England?

Nevertheless, the continued use of plank-built vessels into the Iron Age has not yet been proven. A dugout canoe constructed from a single oak tree but with a fitted transom was discovered in Poole, Dorset, 1964. Here, the added transom demonstrates a method employed to extend a vessel's length; now on display in Poole Museum the vessel is thought to have been capable of carrying up to 18 people. The numerous Iron Age dugouts discovered throughout England in both coastal and inland locations, most recently in 2001 when two seven metre-long oak dugouts were found in peat alongside the River Witham at Fiskerton near Lincoln, suggests their widespread use at this time.

By the Late Iron Age ships had evolved in Northern Europe, and Julius Caesar's *Gallic Wars* evidences a range and type of ocean-going vessels. Describing fighting on the Atlantic coast in 56 BC, Caesar comments that the Gauls' ships were rigged differently to Roman ones; that their exceptionally high bows and sterns fitted them for use in heavy seas; while oak hulls allowed them to withstand shock and rough usage. Significantly, Caesar remarks that some of these vessels' timbers comprised beams a foot wide fastened with iron bolts 'as thick as a man's thumb.' Sadly, the remains of such sturdy vessels are not yet known in England despite evidence of cross-Channel trade at places like Hengistbury Head, Dorset, since at least the Neolithic period.

In antiquity a boat's master would have worked by rule of thumb to ensure safe operational freeboard and adequate stability for his craft. McGrail (1989) argued that it is possible that part-cargoes of stone or heavy metals/alloys (such as lead, copper, tin and bronze) found on protected sites off the south coast of England could remain in a vessel as ballast, or as compensatory low stowage factor materials, until another similar consignment was obtained.

Conclusion

Archaeological remains of ships and boats are usually viewed in a functional way and separate from the peoples who fashioned, built, used and moved them to exchange goods and ideas. This chapter has shown that from at least the start of the Holocene ships and boats provided the only *means* for peoples to move across the seaways surrounding Britain (that is until Blanchard's Dover to Guînes balloon flight in 1785).

On the basis of current evidence, it would seem that there is a shift in early Holocene boat-based mobility from the Southern Bight area in the east to the western seaways by the Neolithic. While more research is needed to understand this shift in greater detail, it is suggested that the change may, in part, be related

to the inundation of the southern North Sea shoals prohibiting previous island-hopping coupled with later migration towards the Cotentin peninsula. The extent to which the technologies of (log)boat construction affected this shift in cross-Channel mobility is not yet understood. By the Bronze Age however, perhaps as a result of plank-built construction, this mobility was unlimited.

Watercraft, whether skin- or logboats, sewn or later trenailed craft, provided a *means* of mobility for our prehistoric ancestors. The typological development of early watercraft is not fully understood, and there are gaps in our understanding. Skin-boats, for example, continue to remain absent from the archaeological record while 'extended' logboats (where rows of planks are attached to the sides of logboats to increase its freeboard enabling Crumlin-Pedersen's so-called *magical transformation* to clinker-built craft – Nymoen 2008) are not yet known in England. Common logboats, that is those types where the finished vessel does not extend beyond the original dimensions of the original tree trunk, are distinguished from expanded craft.

Portage (i.e. the practice of carrying watercraft/cargo over land between river passages) has been evidenced on cleats identified by Nymoen (2008) on the Siljan boat. These parallel those noted by the author at the Must Farm assemblage. While it is easy, in the absence of alternative evidence, to extend comparisons with the *voyageurs* of the North American fur trade (where portages of up to 19 km are not uncommon), it is noteworthy that 'Tarbert' is a common place name in Scotland and Ireland indicating the site of a portage. The *Canoeist's Guide to Expedition Skills* (Conover 1990) shows that poling, lining, portaging and manoeuvring through ice are all possible for the determined traveller: skills not beyond the means of early boat builders.

By the Bronze Age, maritime networks extended along the Atlantic seaboard of Europe and linked to others spanning the Mediterranean though direct evidence of shipping itself is sparse. The Czech *Monoxylon* expeditions demonstrated the possibility of long-distance passage and such mobility may be evidenced by the discoveries made at Salcombe. This assemblage, combined with other limited sites off England's south coast, provide rare chances to view objects in transit; the nearest that archaeology can get to witnessing trade in action rather than trade as inferred from redistributed material. The assemblages contain material of largely northern French in origin, and some of the items from the Langdon Bay site had been cut up to facilitate packing and handling – and perhaps retained a ballast. These sites have the potential to contribute significantly to our understanding of the nature and purpose of Bronze Age exchange, and the extent to which it underpinned social structures and economic growth.

The vessels themselves were well suited to cabotage – the practice of trade or navigation in coastal waters. This necessitated both geographic and navigational knowledge and it is possible that the knowledge of nautical astronomy derived from observations of the relative movements of the sun, moon, planets and stars was built into a tradition to determine direction, time and season.

The relationship of the prehistoric metaphysical importance of watercraft and mobility has not fully been explored in this chapter. The 'solar barge' (i.e. the mythological representation of the sun riding in a vessel), as interpreted across the ancient world within Neolithic and Bronze Age petroglyphs, the Nebra sky disc and of course Egyptian sun deities, clearly has a relationship with movement (i.e. the passage of the sun) and navigation. Our association with, and longing for, the sea has a connection with spiritual belief and may explain why, for some, the sea is 'in their blood'. It may be that the ancient mariners hoped to return from voyages in the same way that Ra emerges in the east in his solar barge each morning.

References

Anderson, S. 1987. Mesolithic dug-outs and paddles from Tybrind Vig, Denmark. *Acta Archaeologica*, 57, 87–106.

Anon, 2012. Falmouth's pioneering vessel. *Current Archaeology*, 272 (Nov 2012), 10.

BBC News 2012. *Gower cave reindeer carving is Britain's oldest rock art* [Online]. Available at: http://www.bbc.co.uk/news/uk-wales-south-west-wales-18648683 (accessed: 25 October 2012).

Bonnin, P. 2000. Découverte de deux pirogues monoxyles mésolithiques entre Corbeil-Essonnes (Essonne) et Melun (Seine-et-Marne), in *Les Derniers Chasseurs-Cueilleurs d'Europe Occidentale, Actes du Colloque International de Besançon, October 1998*, edited by A. Richard, C. Cupillard, H. Richard, A. Thevenin. Besançon: Presses Universitaires Franc-Comtoises (Annales Littéraires, 699; Série 'Environment, Sociétés et Archéologie'), 305–11.

Burov, G.M. 1996. On Mesolithic means of water transportation in north Eastern Europe. *Mesolithic Miscellany*, 17(1), 5–15.

Conover, G. 1990. *Beyond the Paddle: A Canoeist's Guide to Expedition Skills-Polling, Lining, Portaging, and Manoeuvring Through Ice*. Gardiner, ME: Tilbury House.

Ellmers, D. 2008. *Frühmittelalterliche Handelsschiffahrt in Mittel- und Nordeuropa*. Neumünster: Wachholtz Verlag Gmbh.

Gjerde, J.M. 2010. Rock art and landscapes: Studies of Stone Age rock art from northern Fennoscandia. Unpublished PhD thesis, University of Tromsø.

Keys, D. 2013. It didn't sink! Full-size, sewn-together replica of a Bronze Age boat launched to trials success. *The Independent*, 06 March [Online]. Available at: http://www.independent.co.uk/news/science/archaeology/it-didnt-sink-fullsize-sewntogether-replica-of-a-bronze-age-boat-launched-to-trials-success-8521472.html [accessed: 16 July 2013].

Knight, M. 2012. *Must Farm Must Read*. [Online]. Available at: http://www.mustfarm.com [accessed: 17 December 2012].

Lanting, J.N. 2000. Dates for origin and diffusion of the European logboat. *Palaeohistoria*, 39/40 (1997/1998), 627–50.

Luukkanen, H. 2009. *On the diffusion of the bark canoes, skin boats and expanded log boats in the Eurasian North*. Paper to the A Circumpolar Reappraisal conference: Trondheim, 11–13th October 2008.

Mainberger, M. 2009. An Early Bronze Age logboat from Degersee, Southern Germany. *International Journal of Nautical Archaeology*, 38(1), 3–12.

McGrail, S. 1989. The shipment of traded goods and of ballast in antiquity. *Oxford Journal of Archaeology*, 8, 353–8.

Niblett, R. 2001. A Neolithic dugout from a multi-period site near St Albans, Herts, England. *International Journal of Nautical Archaeology*, 30(2), 155–95.

Nymoen, P. 2008. Boats for rivers and mountains: Sources for new narratives about river travel? *International Journal of Nautical Archaeology*, 37(1), 3–16.

Parham, D., Needham, S. and Palmer, M. 2006. Questioning the wrecks of time. *British Archaeology*, 91 (November/December), 43–7.

Peacock, D. and Cutler, L. 2010. A Neolithic voyage. *International Journal of Nautical Archaeology*, 39(1), 116–24.

Peeters, H., Murphy, P. and Flemming, N. 2009. *North Sea Prehistory Research and Management Framework (NSPRMF)*. Amersfoort: Rijksdienst voor het Cultureel Erfgoed/English Heritage.

Pickard, C. and Bonsall, C. 2007. Late Mesolithic coastal fishing practices – the evidence from Tybrind Vig, Denmark, in *On the Road. Studies in Honour of Lars Larsson*, edited by B. Hårdh, K. Jennbert, and D. Olausson. Stockholm: Almqvist and Wiksell (Acta Archaeologica Lundensia 4, No. 26), 176–83.

Severin, T. 2000. *The Brendan Voyage*. New York: Modern Library.

Sheridan, A. 2007. From Picardie to Pickering and Pencraig Hill? New information on the 'Carinated Bowl Neolithic' in northern Britain, in *Going Over: The Mesolithic-Neolithic Transition in North-West Europe*, edited by A. Whittle and V. Cummings. Oxford: British Academy and Oxford University Press, 441–92.

Tichý, R. (nd). *The Sea Navigation in Early Neolithic Period. A Contribution of Experimental Archaeology to the Beginnings of Mediterranean Neolithization* [Online]. Available at: http://www.mamuti.cz/experimenty/monoxylon.aspx [accessed: 31October 2012].

Van de Noort, R. 2011. *North Sea Archaeologies. A Maritime Biography, 10,000 BC – AD 1500*. Oxford: Oxford University Press.

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